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ECONOMIC NOTES NO. 9 APRIL 1938

# METHODS OF PREDICTING GROWTH OF FOREST STANDS

## IN THE FOREST SURVEY OF THE LAKE STATES

LAKE STATES FOREST EXPERIMENT STATION
UNIVERSITY FARM - ST. PAUL, MINNESOTA
U.S. DEPARTMENT OF AGRICULTURE
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Economic Notes No. 9 April 1938

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## in the Forest Survey of the Lake States

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LAKE STATES FOREST EXPERIMENT STATION
University Farm, St. Paul, Minnesota

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# METHODS OF PREDICTING GROWTH OF FOREST STANDS

## In the Forest Survey of the Lake States

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## INTRODUCTION

An important phase of the Forest Survey is that dealing with the growth and development of timber stands. The Lake States Forest Experiment Station, which is responsible for the Survey in Michigan, Wisconsin, Minnesota, South Dakota, and Kansas, has devoted a considerable amount of both field and office work to obtaining a reasonably accurate appraisal of the growth of forests in these States. Some of the methods developed for predicting growth are described here. It is believed that these methods may be found helpful in making other surveys or local management plans in this region.

Three general types of growth calculations were required: (1) current (10-year average) growth, for comparison with current depletion through cutting, fire, and other causes; (2) growth for periods of 20 to 60 years in the future, as a basis for judging the character of the forest which would result if existing young stands were reserved from cutting; and (3) mean annual growth over a complete rotation under various degrees of protection and various types of management. The first called for a study of the diameter increment of trees, and an estimate of mortality due to competition, windthrow, and decay; the second and third called for the use of yield tables.

Few normal-yield tables are available for the forest types of the Lake States, and the ones which exist assume utilization and cull standards very different from those used in the Survey. For these reasons, yield tables applicable to Survey standards had to be prepared. Furthermore, in the course of the growth work, special tables were developed for calculating the current growth of uneven-aged, understocked, and cut-over stands such as are found in the region.

Most of the tables presented on the following pages are based upon the standards of merchantability used in the Forest Survey. In applying these tables, therefore, either the same standards should be followed or suitable allowances should be made. Merchantability standards and basic volume tables are given in Appendix A.

The procedures outlined here are those which proved most satisfactory in operation, and will probably be followed in future extensions of the growth studies.

Section 1. -- CALCULATING CURRENT GROWTH BY MEANS OF INCREMENT CORES

There are several methods of using increment cores to calculate growth of a timber stand for short periods in the future. In general, they involve (1) reducing the present stand table to allow for anticipated mortality and cull losses, and (2) calculating growth on this reduced stand. Two methods which were used in the Forest Survey will be described.

## Stand-Table Method

The stand-table method of estimating current growth involved the following calculations for each forest cover type and size class of stand[1]:

1. Preparation of a stand table showing numbers of trees per acre by diameter-breast-high (d.b.h.) classes. This, of course, was a part of the inventory phase of the Survey.

2. Reduction of these numbers of trees to allow for the expected loss through mortality and cull in each d.b.h. class.

3. Construction of a curve showing 10-year diameter increment (at breast height) by d.b.h. class. Data for this curve were obtained from increment borings taken on the inventory plots. To determine increment by d.b.h. class, the sample trees were grouped not according to their present diameters but according to their diameters 10 years ago. Thus the curve obtained could be used to predict future increment on the basis of increment in the past. The width of the 10 annual rings, after being doubled to apply to diameter, was corrected to allow for increment of bark. Factors for this correction are given in table XXVIII of the appendix.

4. Preparation of a curve showing the average net volume of all trees except culls in each d.b.h. class.[2] This, again, was a part of the inventory phase of the Survey.

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[1] A complete discussion of cover types, size classes, and other types of classification used in the Forest Survey is to be found in Economic Notes No. 4, Introduction to Reports of the Forest Survey of the Lake States.

[2] While net volume was used in the Survey calculation, gross volumes, if preferred, can be used equally well in this method. See Appendix A.

5. Computation of 10-year growth in four steps: (a) For each d.b.h. class in the stand table the d.b.h. expected 10 years hence was read from the diameter-increment curve (paragraph 3). (b) Present and future volumes per tree corresponding to these diameters were read from the volume-over-diameter curve (paragraph 4). (c) The difference between present and future volumes for each d.b.h. class was recorded as 10-year growth per tree. (d) These differences were multiplied by the corresponding numbers of trees (paragraph 2). The products were then added together to obtain total 10-year growth per acre.

A discussion of mortality and cull losses is presented on pages 12 to 13. The other steps in the growth calculation are illustrated in table 1:

Table 1. -- Sample Calculation of Growth by the Stand-Table Method

| Step a | | Step b | | Step c | Step d | |
|---|---|---|---|---|---|---|
| Present d.b.h. class (inches) | D.b.h. 10 years hence | Sawlog volume per tree | | Growth per tree | Trees per acre[1] | Growth per acre in 10 years |
| | | Now | 10 years hence | | | |
| | Inches | Bd.ft. | Bd.ft. | Bd.ft. | Number | Bd.ft. |
| [2]10 | 11.0 | 30 | 44 | 14 | 10 | 140 |
| 12 | 13.5 | 60 | 91 | 31 | 8 | 248 |
| 14 | 15.8 | 102 | 150 | 48 | 6 | 288 |
| 16 | 18.0 | 154 | 216 | 62 | 4 | 248 |
| 18 | 20.0 | 216 | 296 | 80 | 2 | 160 |
| 20 | 22.0 | 296 | 383 | 87 | 3 | 261 |
| 22 | 23.9 | 383 | 480 | 97 | 2 | 194 |
| 24 | 25.8 | 483 | 578 | 95 | 2 | 190 |
| 26 | 27.7 | 587 | 682 | 95 | 1 | 95 |
| All | ..... | ..... | ..... | ..... | 38 | 1,824 |
| Average per year | | | | | | 182 |

[1]/Reduced for anticipated mortality and cull losses.

[2]/The 10-inch d.b.h. class includes trees with diameters ranging from 9.0 to 10.9 inches, inclusive.

This method of estimating growth, in common with other increment-core methods, assumes (1) that the relation between diameter increment and d.b.h. for the past 10-year period will hold true for the next decade; (2) that the volume table for the present stand will be applicable to the stand 10 years hence; and (3) (if net volume is used) that the percentage of woods and mill cull in each d.b.h. class will remain the same during the period.

Somewhat greater accuracy can be attained by working out the volume growth of individual trees and averaging the results, rather than dealing with the average diameter increment for each d.b.h. class.

In the illustration, no allowance is made for the growth of trees of less than merchantable size (less than 9 inches in d.b.h.). Whereas in a given stand the 8-inch trees, for example, as a class may fail to advance to merchantability in 10 years, individual trees of this class may do so. This fact should be taken into consideration. (A method of allowing for the growth of trees of less than merchantable size is presented on pages 8 to 10.)

## Modification of Stand-Table Method

Another form of the stand-table method makes use of a table, based upon increment cores, showing what percentage of the total number of trees in any d.b.h. class may be expected to advance into larger classes during a given period. Such a table (table 2) is presented on page 5 for the northern-hardwood cover type. A stand table for the average acre 10 years hence can be prepared for stands of this type by applying proportions obtained from table 2 to the present stand table (reduced for mortality and cull losses). For example, if the reduced number of 10-inch trees on the average acre is 19, and their anticipated average diameter increment in 10 years is 1.2 inches, table 2 indicates that 7 (37 percent) of the trees may be expected to remain in the 10-inch class, and 12 (63 percent) to pass into the 12-inch class. None will become 14-inch trees. The rest of the calculation is similar to that in table 1.

## Growth-Percent Method[3/]

Current annual growth of individual trees can be expressed as a percentage of their present volume, and their growth over a short period calculated by compounding this current interest on capital. Current annual

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3/ The formulas presented in this discussion are adaptations of the one given in an article by S. R. Gevorkiantz: A New Growth Percent Formula. Jour. Forestry 25:44-49. 1927.

Table 2. -- Probability of Trees in any 2-inch D.B.H. Class Growing into Larger D.B.H. Classes, in Relation to Their Average Increment in Diameter[1/]

| Average increment in d.b.h. (inches) | Portion of total number of trees that will -- | | | | |
|---|---|---|---|---|---|
| | Remain in same d.b.h. class | Grow into indicated larger 2-inch d.b.h. class | | | |
| | | Next | 2nd | 3rd | 4th |
| | Percent | Percent | Percent | Percent | Percent |
| 0.2 | 100 | | | | |
| 0.4 | 100 | | | | |
| 0.6 | 92 | 8 | | | |
| 0.8 | 68 | 32 | | | |
| 1.0 | 50 | 50 | | | |
| 1.2 | 37 | 63 | | | |
| 1.4 | 28 | 71 | 1 | | |
| 1.6 | 21 | 75 | 4 | | |
| 1.8 | 18 | 73 | 9 | | |
| 2.0 | 15 | 69 | 16 | | |
| 2.5 | 10 | 56 | 32 | 2 | |
| 3.0 | 8 | 42 | 41 | 9 | |
| 3.5 | 7 | 31 | 43 | 17 | 2 |
| 4.0 | 6 | 24 | 39 | 25 | 6 |

[1/] This table was prepared from diameter-increment data obtained in stands of northern hardwoods in Michigan and Wisconsin.

growth percent of any tree in terms of cubic feet[4/] can be computed approximately by the formula

$$P = 24 \frac{g}{D},$$

where

P = annual growth percent,
g = expected 10-year increment in d.b.h. (inches), and
D = present d.b.h. (inches).

[4/] See Appendix A.

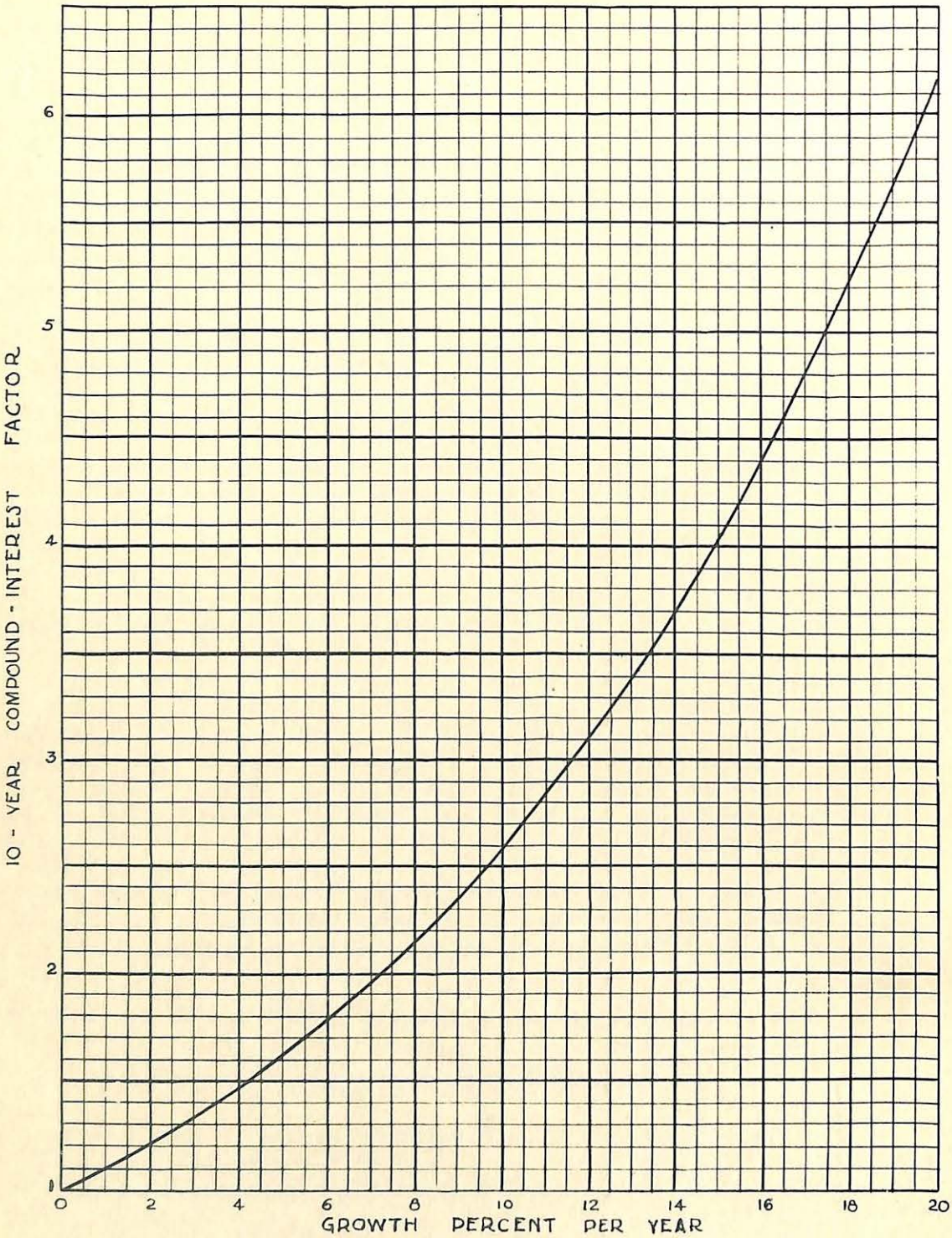


Figure 1. -- Value, 10 years hence, of one unit of capital accumulated at various rates of compound interest.

Similarly, annual growth percent of sawlog volume in board feet, Scribner[5], is approximately expressed by the formula

$$P = 25 \frac{g}{D} .$$

When the merchantable height of a tree, however, is definitely fixed by the position of large limbs or other deformities which will continue to limit its merchantability, then the following formula should be used to determine growth percent of sawlog volume:

$$P = 23 \frac{g}{D} .$$

This last condition is very common among mature hardwoods in the Lake States. According to the formula, for example, a 20-inch tree with an expected 10-year diameter increment of 1.74 inches will grow in volume at the rate of

$$\frac{23 \times 1.74}{20} = 2 \text{ percent per year.}$$

Compound-interest tables show that a unit of capital growing at the rate of 2 percent annually will have increased to 1.219 units at the end of 10 years. This means that if the present sawlog volume of the tree is 300 board feet, Scribner, its volume 10 years hence will be 300 x 1.219, or 366 board feet. A curve showing the value, 10 years hence, of one unit of capital accumulated at various rates of compound interest appears as figure 1.

In using the growth-percent method in the Forest Survey it was found convenient to prepare growth-percent tables based upon the Survey standards of cull and merchantability.[6] Such tables (see appendix tables XXIV, XXV, and XXVI) will be found applicable in any growth predictions in which the same standards are employed and merchantable heights are approximately the same as those given in table I of the appendix. Here, the use of compound-interest tables is not required.

A sample calculation, for a stand of mixed maple and basswood for which a 10-year growth estimate is required, is shown in table 3. Numbers of trees (reduced for mortality and cull losses) and corresponding net volumes per acre in board feet, Scribner, are tabulated by d.b.h. classes. Opposite each d.b.h. class is recorded the 10-year diameter increment, obtained as in the stand-table method. Growth percentages are read from the

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[5] See Appendix A. Sawlog volume may be either net or gross.

[6] See Appendix A, especially table I.

board-foot table (appendix table XXIV). Applied to present volumes, these percentages give net growth in board feet, Scribner.

Table 3. -- Sample Calculation of Growth in a Maple-Basswood Stand by the Growth-Percent Method

| D.b.h. class (inches) | Trees per acre[1] | Volume, Scribner rule | | Average 10-year diameter increment | Growth per acre in 10 years | |
|---|---|---|---|---|---|---|
| | | Per tree[2] | Per acre | | | |
| | Number | Bd.ft. | Bd.ft. | Inches | Percent | Bd.ft., Scribner |
| 6..... | 51 | ..... | ..... | 0.80 | ..... | ..... |
| 8..... | 36 | ..... | ..... | 0.90 | ..... | ..... |
| 10..... | 25 | 12 | 300 | 1.00 | 126.0 | 378 |
| 12..... | 15 | 43 | 645 | 1.05 | 39.4 | 254 |
| 14..... | 8 | 79 | 632 | 1.10 | 28.2 | 178 |
| 16..... | 4 | 123 | 492 | 1.10 | 22.7 | 112 |
| 18..... | 1 | 171 | 171 | 1.10 | 19.0 | 32 |
| All..... | 140 | ..... | 2,240 | ..... | ..... | 954 |

[1] Reduced for anticipated mortality and cull losses.

[2] Volumes in each d.b.h. class are averages for all sound trees, including those which, because of rapid taper, now contain no sawlog volume.

## Growth of Unmerchantable Trees

When either the growth-percent method or the regular stand-table method is used, the growth of trees which, simply because of their small size, are now unmerchantable and thus are considered to have no volume must be calculated separately. The modified stand-table method presents a ready means of making this calculation. Use is made of a table (such as table 2, for northern hardwoods) prepared from increment cores, showing the proportion of unmerchantable trees which will graduate into merchantable size. Referring again to the maple-basswood stand illustrated above, table 2 shows that of the 6-inch trees growing an average of 0.80 inch in diameter in 10 years, none will graduate into the 10-inch or larger d.b.h. classes during the period. However, in the case of the 36 8-inch trees (growing an average of 0.90 inch in diameter in 10 years), it is found by interpolation that 41 percent, or approximately 15 trees, will become 10-inch trees within 10 years. Since the average sawlog volume of all sound

10-inch trees is 12 board feet, this means that an additional growth of 12 x 15, or 180, board feet will accrue in 10 years from 8-inch trees.

Adding the 180-board-foot growth of unmerchantable trees to the growth of the merchantable stand (954 board feet) calculated in table 3, the total net growth of this maple-basswood stand is found to be 1,134 board feet, Scribner, per acre in 10 years, or 113 board feet per acre per year.

For the general run of timber stands in the Lake States, and in all cases in which the Forest Survey standards of merchantability are followed, allowances for growth of trees of less than merchantable size can be calculated, in the appropriate unit of volume, by use of table 4.

Table 4. -- Allowance for Additions to Merchantable Stand[1/]

| Average increment in d.b.h. (inches) | Allowance for addition to -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Net volume in board feet, Scribner rule | | | | Volume in cubic feet | | Volume in cords | |
| | Hardwoods | | Conifers and aspen | | 2-inch trees | 4-inch trees | 2-inch trees | 4-inch trees |
| | 6-inch trees | 8-inch trees | 6-inch trees | 8-inch trees | | | | |
| | Percent | Percent | Percent | Percent | Percent | Percent | Percent | Percent |
| 0.2..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 0.4..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 0.6..... | ..... | 1.3 | ..... | 2.5 | ..... | 1.6 | ..... | 1.7 |
| 0.8..... | ..... | 5.1 | ..... | 9.9 | ..... | 6.4 | ..... | 6.7 |
| 1.0..... | ..... | 7.9 | ..... | 15.4 | ..... | 10.0 | ..... | 10.5 |
| 1.2..... | ..... | 10.0 | ..... | 19.4 | ..... | 12.6 | ..... | 13.2 |
| 1.4..... | 0.2 | 11.8 | 0.3 | 22.5 | 0.2 | 14.7 | 0.2 | 15.4 |
| 1.6..... | 0.6 | 14.1 | 1.2 | 25.4 | 0.8 | 17.1 | 0.8 | 17.9 |
| 1.8..... | 1.4 | 16.6 | 2.8 | 27.8 | 1.8 | 19.3 | 1.9 | 20.1 |
| 2.0..... | 2.5 | 19.9 | 4.9 | 30.6 | 3.2 | 22.2 | 3.4 | 23.1 |
| 2.5..... | 6.2 | 28.8 | 11.1 | 38.0 | 7.4 | 29.9 | 7.8 | 30.9 |
| 3.0..... | 11.6 | 38.7 | 17.9 | 46.0 | 12.9 | 38.8 | 13.4 | 39.7 |
| 3.5..... | 18.4 | 49.2 | 25.2 | 54.8 | 19.5 | 49.0 | 20.1 | 49.6 |
| 4.0..... | 26.3 | 60.0 | 32.7 | 64.5 | 26.8 | 59.9 | 27.5 | 60.3 |

[1/] Based on 2-inch d.b.h. classification. For net volume in board feet, the allowance is in percentage of the volume of a 14-inch tree; for volume in cubic feet or cords, it is in percentage of the volume of a 10-inch tree. This table is based upon Forest Survey standards of merchantability (see Appendix A).

For the example of the maple-basswood stand in table 3, the growth of 8-inch trees is found as follows:

1. Under board feet in table 4 find the allowance for 8-inch hardwoods growing at the average rate of 0.9 inch in d.b.h. in 10 years. This allowance is found, by interpolation, to be 6.5 percent.

2. Find the net volume of a 14-inch tree (see note 1, table 4), and calculate 6.5 percent of this value: 6.5 percent of 79 board feet equals 5.135 board feet. This is the expected 10-year growth of the average 8-inch tree.

3. Multiply this growth per tree by the number of 8-inch trees in the stand (reduced for mortality and cull losses): 5.135 x 36 = 185 board feet. This is the expected 10-year growth of all 8-inch trees.

The allowance of 185 board feet, based on regional averages, checks reasonably well with the value of 180 board feet obtained from the northern-hardwood table (p. 9).

## Growth in Additional Cords

It is often necessary to know not only the growth in board feet but also the growth, in cords, of material not suitable for sawlogs -- that is, tops, limbs, and cull sections of sawlog trees, and trees of less than sawlog size. This growth is here referred to as "growth in additional cords."

Tables 5 and 6 give factors for computing growth in additional cords for hardwood types. The tables are based upon the standards of merchantability used in the Forest Survey (see Appendix A).

An example in point is an oak farm woodland in southeastern Minnesota, having a net Scribner volume of about 3,000 board feet of sawlogs per acre. Including cordwood material, the total volume per acre is 30 cords. By methods previously described it was found that the increase of this total cordwood volume amounts to 0.74 cord per acre per year. The growth of this stand in additional cords may be found as follows:

1. Determine the ratio of board-foot to total cordwood volume of the stand. Thus,

$$\frac{3,000}{30} = 100.$$

2. Opposite 100 in table 5 read the conversion factor of 73 percent. This is the growth in additional cords as a percentage of the growth in total cords.

Table 5. -- Conversion Table for Growth in Additional Cords in Hardwood Stands

| Ratio of net sawlog volume in board feet, Scribner, to total volume in cords | Growth in additional cords in terms of growth in total cords | Ratio of net sawlog volume in board feet, Scribner, to total volume in cords | Growth in additional cords in terms of growth in total cords |
|---|---|---|---|
| | Percent | | Percent |
| 10 | 98 | 90 | 76 |
| 20 | 96 | 100 | 73 |
| 30 | 93 | 120 | 67 |
| 40 | 91 | 140 | 61 |
| 50 | 88 | 160 | 54 |
| 60 | 85 | 200 | 42 |
| 70 | 82 | 250 | 24 |
| 80 | 79 | 300 | 5 |

3. Multiply growth in total cords by this factor in order to obtain an estimate of growth in additional cords:

0.74 x 0.73 = 0.54 cord per acre per year.

4. Reduce the above estimate to allow for the fact that some small trees and parts of larger trees will grow out of the "additional cords" classification into the "sawlog" classification. Table 6 gives a basis for making this reduction. By means of borings it is found that the average d.b.h. increment of merchantable sawlog and cordwood trees in

Table 6. -- Reduction Table for Growth in Additional Cords in Hardwood Stands

| Average 10-year d.b.h. increment of merchantable trees (inches) | Reduction per 100 8-inch trees | Average 10-year d.b.h. increment of merchantable trees (inches) | Reduction per 100 8-inch trees |
|---|---|---|---|
| | Cords | | Cords |
| 0.4 | | 1.4 | 2.0 |
| 0.6 | 0.5 | 1.6 | 2.0 |
| 0.8 | 1.0 | 1.8 | 2.5 |
| 1.0 | 1.5 | 2.0 | 3.0 |
| 1.2 | 2.0 | 3.0 | 7.0 |

the stand is 1 inch in 10 years. According to table 6 the corresponding reduction in additional-cord growth per acre is 1.5 cords per 100 8-inch trees. There are 40 8-inch trees in this stand. Thus the reduction is

$$\frac{40}{100} \times 1.5 = 0.60 \text{ cord per acre in 10 years,}$$

or 0.06 cord per year. The corrected value for growth in additional cords, then, is

$$0.54 - 0.06 = 0.48 \text{ cord per acre per year.}$$

This means that of the total volume of 0.74 cord per acre which is added to the stand every year, 0.48 cord consists of material other than sawlogs and the remaining 0.26 cord consists of merchantable sawlogs.

## Mortality and Cull Losses

There is no thoroughly satisfactory method of estimating mortality and cull losses on the basis of existing stands. In the course of the Survey several methods were tried, such as tallying on sample plots the numbers of trees which had apparently died or become culls during the preceding 10 years and studying the relation between number of sound trees per acre and average diameter of stands of different densities and size classes. Use of permanent-sample-plot data was also attempted.

In Minnesota the basis chosen for estimating mortality and cull losses was a comparison of more or less undisturbed stands in various stages of development. In this comparison it was found that number of sound trees declines regularly as average stand diameter increases. The rate of this decline is influenced by the character of the forest type (tolerance, longevity, and general thrift of the principal species) and by the rate of growth. Fast-growing and early maturing types, such as aspen and pines, become overcrowded more rapidly than slow-growing types like the swamp conifers.

In applying the results of this mortality study it was found expedient to deduct mortality and cull losses not from the present number of trees but from a provisional growth figure obtained by calculating the total growth of every sound tree in the stand. For example, if a stand contained altogether 50 trees per acre, its growth for the next 10 years was estimated not by reducing these 50 trees to (say) 45 to allow for mortality and cull, and calculating the growth of this net number of trees as previously described, but rather by assuming provisionally that all 50 trees would grow at the average rate, and then reducing this provisional growth by the correct amount. It should be understood, of course, that this reduction allowed not only for mortality and cull losses, proper, but also for the assumed growth of those trees (in this example, 5) which were expected to die or become culls during the period.

Table 7 presents in condensed form the reduction factors used to correct the provisional growth estimates made in Minnesota. These reduction factors are, strictly speaking, applicable only to undisturbed stands and over large areas and, furthermore, are long-term averages.

Table 7. -- Factors[1/] for Reducing Provisional Growth Estimates, by Forest Cover Type

| Provisional growth of next 10 years, in terms of present stand volume (percent) | Growth of next 10 years, in terms of provisional growth | | |
|---|---|---|---|
| | Pines and aspen | Hardwoods and spruce-fir | Swamp conifers |
| | Percent | Percent | Percent |
| 20 | ..... | 4 | 46 |
| 30 | 18 | 31 | 61 |
| 40 | 34 | 44 | 68 |
| 50 | 43 | 52 | 73 |
| 60 | 49 | 57 | 76 |
| 70 | 54 | 61 | 78 |
| 80 | 57 | 64 | 80 |
| 90 | 60 | 66 | 81 |
| 100 | 62 | 68 | 82 |
| 200 | 71 | 76 | 86 |
| 400 | 76 | 80 | 89 |
| 600 | 78 | 81 | 89 |
| 800 | 79 | 82 | 90 |
| 1,000 | 79 | 82 | 90 |
| 2,000 | 80 | 83 | 90 |
| 3,000 | 80 | 84 | 91 |

[1/] These factors apply to growth (in any unit of volume) obtained on the basis of Forest Survey standards of merchantability.

As an example of use of the reduction factors in table 7, take a stand of red pine in north-central Minnesota for which a 10-year growth estimate is required. This stand contains 5,000 board feet per acre. Its provisional growth is computed by any of the increment-core methods previously described, on the basis of total number of trees in the present stand. The 10-year provisional growth of the entire stand, including trees now of less than sawlog size, is found to be 3,000 board feet per acre. Provisional growth, then, amounts to 60 percent of present volume. By reference to table 7 the reduction factor for a provisional growth of 60 percent is found to be 49 percent. Growth, then, is 49 percent of 3,000, or 1,470, board feet per acre, in 10 years (or 147 board feet per acre per year).

## Section 2. -- CALCULATING GROWTH BY MEANS OF GROWTH AND YIELD TABLES

In order to obtain a basis for estimating growth not only for short periods but for long periods as well, a special field study was made in timber stands undisturbed by recent cutting or fire. About 150 sample plots were taken in each of the principal cover types. These were selected more or less mechanically, on areas well scattered over the Lake States region. On the basis of results of the study growth and yield tables were prepared for the main cover types.

### Factors Affecting Growth[7/]

Volume growth in a timber stand depends chiefly upon four factors: (1) age, (2) site quality, (3) density, and (4) proportion of merchantable to unmerchantable trees in the stand, represented by "merchantability index." Growth prediction is a matter of evaluating the effect of each of these four factors.

A large proportion of the timber stands in the Lake States are not truly even-aged. Most of them contain a few trees which are remnants of a former stand, and many contain an understory of recently established reproduction. To avoid the confusion which would result from dealing with all these trees the age of each stand was taken to be that of the main group of trees. A typical age distribution in cordwood stands is shown in figure 2,A. In this figure numbers of trees have been plotted by age classes. The prominence of the main stand is shown clearly.

The trees on each sample plot taken in the special field study were classified by age group -- that is, as younger individuals, main body, and former stand. Judgment of age group was based upon experience, supplemented by borings. Main-stand trees were generally distinguishable by the following characteristics:

1. Their ages are rather closely distributed around the average for the stand.

2. They contain most of the volume and most of the basal area.

3. Their ages are set off, often by considerable gaps, from those of other trees.

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7/ The principles underlying this discussion are explained in detail in an article by William A. Duerr and S. R. Gevorkiantz: Growth Prediction and Site Determination in Uneven-aged Timber Stands. Jour. Agr. Research 56:81-98. 1938.

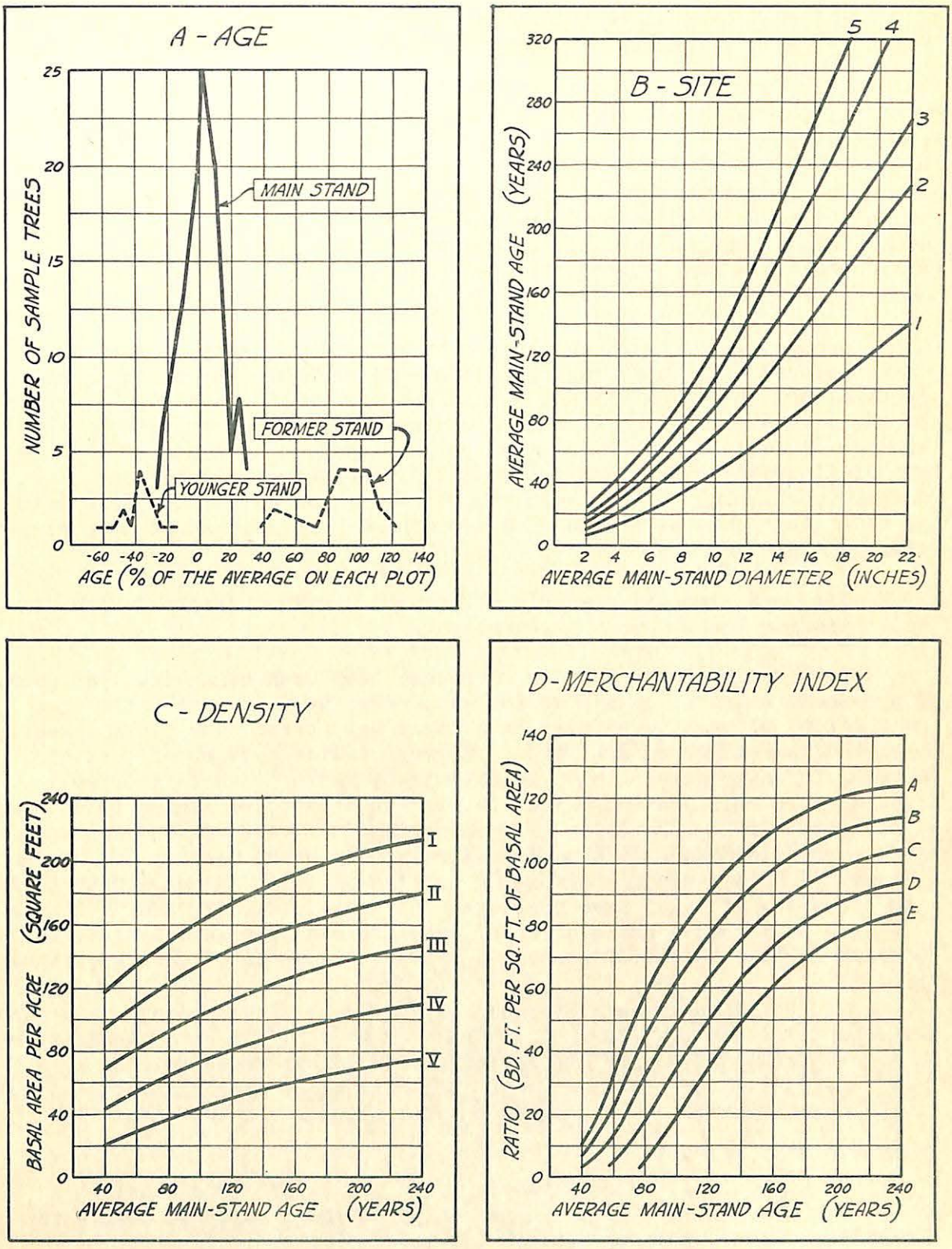
A - AGE
NUMBER OF SAMPLE TREES
MAIN STAND
FORMER STAND
YOUNGER STAND
AGE (% OF THE AVERAGE ON EACH PLOT)
B - SITE
AVERAGE MAIN-STAND AGE (YEARS)
AVERAGE MAIN-STAND DIAMETER (INCHES)
C - DENSITY
BASAL AREA PER ACRE (SQUARE FEET)
AVERAGE MAIN-STAND AGE (YEARS)
D - MERCHANTABILITY INDEX
RATIO (BD. FT. PER SQ. FT. OF BASAL AREA)
AVERAGE MAIN-STAND AGE (YEARS)

Figure 2. -- The four chief factors which affect growth, illustrated by the northern-hardwood cover type in the Lake States.

Not less than three age-sample trees were bored on each plot, as this was found to be the minimum consistent with the size of the sample taken.

In even-aged timber, of course, identification of the main stand is a simple matter.

The accepted index of site quality is the relation between age and height of dominant trees. This index, however, has not proved readily applicable to uneven-aged stands. A site index found more usable for these stands is the relation between age and average diameter of the main stand.

Apparently, growing conditions on some plots are such that the main stand reaches a given average diameter in a much shorter period than is required on other plots. On the northern hardwood type plots, for example if the main stand had an average diameter of 12 inches it had, on the average, an age of 120 years. But on some individual plots of this type and diameter the main stand was as old as 160 years, and on some it was only 80 years old. It has been assumed that this difference is a matter of site; that the better the site the younger the main stand of a given average diameter.

Figure 2,B presents sample site-index curves. The best site, in this case, is labeled 1; the poorest, 5.

Total stand basal area per acre has been used as an index of density The procedure was to construct for each cover type a curve (see curve I, figure 2,C) of basal area over main-stand age, based upon plots taken in well-stocked stands of that type. Survey studies have shown that the growth of understocked stands is relatively faster than that of well-stocked or normal stands -- that is, that understocked stands tend to approach normality. They have also shown that the rate of this approach for a given species and site depends entirely upon stand density and can be determined from a simple formula.[8/] On the basis of these studies a series of curves of basal area over age (curves II, III, IV, and V, figure 2,C) was constructed for each cover type, tracing the development, in respect to basal area, of stands of different degrees of understocking.

The relative numbers of trees of different sizes present in a stand have an important bearing upon its rate of growth. In some stands there are many trees just under merchantable size; these trees have no volume now, but during the next few years they will become merchantable and contribute considerably to the stand's total growth. On the other hand,

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8/ This formula is embodied in table 11, p. 23. See also:
Gevorkiantz, S. R. The Approach of Northern Hardwood Stands to Normality. Jour. Forestry 35:487-489. 1937.
Duerr, William A. Comments on the General Application of Gehrhardt's Formula for Approach Toward Normality. Jour. Forestry (in press).

there are stands which contain few such trees and in which growth occurs chiefly in trees already merchantable.

A dependable clue to distribution of tree diameters in a stand is the ratio of volume to basal area -- for example, the number of board feet per square foot of basal area. This ratio is here termed "merchantability index," because it is a measure of the proportion of merchantable volume in a stand. It is low in stands containing a large proportion of unmerchantable trees; it is high in stands deficient in small trees.

A set of merchantability-index curves showing the normal change in merchantability index with increasing age was drawn up for each cover type. An example is shown in figure 2,D.

Basal-area and merchantability-index curves corresponding to those in figure 2 were made for other than average sites, on the basis of the site-index curves.

By means of the curves a short-range growth prediction can be made in four steps:

1. The stand in question is examined to determine its average main-stand age, site quality, basal area per acre, and ratio of volume to basal area (merchantability index).

2. The present basal area is projected ahead for the required number of years, by use of the basal-area curve for the site quality and density represented.

3. The merchantability index is projected ahead in essentially the same way.

4. The future basal area multiplied by the future merchantability index gives the expected future volume. The difference between this and the present volume is growth for the period.

## Growth Tables

In order to simplify this procedure for determining growth and to eliminate the necessity of making several curve readings and interpolations, the basal-area and merchantability-index trends have been expressed in the form of simple factors. These factors automatically allow for density, the approach of understocked stands toward normality, and merchantability index. Growth of any stand (g) is expressible in the general form

$$g = vA - vbB + bC - b^2D,$$

where v and b are present stand volume and basal area, respectively, and

the capital letters represent the growth factors. Appendix tables IV through XII present board-foot and cubic-foot growth factors by age class for the various cover types. These tables are for use in making 10-year predictions. They apply to medium sites only, except in the case of aspen. The question of site quality is considered on pages 21 to 22.

In order to use the growth tables to predict growth of any stand on a given site it is necessary merely to know the stand's age, basal area, and volume.

Age as used in the tables is average age of main-stand trees only. Ideally, age should be determined from sample trees of the main stand classified in the field. If this is not possible, an approximation may be had by determining the average age of trees belonging to certain key diameter classes, chosen according to the size class of the stand in question. Key diameters for different size classes of timber of any cover type are presented in table 8.

Table 8. -- Key Diameter Classes for Determining Main-Stand Age

| Size class of stand (inches) | Key diameter classes | Size class of stand (inches) | Key diameter classes |
|---|---|---|---|
| | Inches | | Inches |
| 0-5 | 2, 4 | 9-15 | 10, 12, 14 |
| 3-9 | 6, 8 | 15+ | 14, 16, 18, 20 |

Basal area, as here considered, is the basal area of the entire stand of trees 1 inch and larger in diameter breast high, excluding cull trees.

The growth tables can be used to determine growth in both board feet and cubic feet. They are based upon the merchantability standards discussed in Appendix A, and specifically upon the volumes given in appendix tables II and III. These standards should be kept in mind in interpreting values calculated from the growth tables. For instance, the board-foot growth does not include standing cull trees or upper portions of tree stems where defect, deformity, or branching makes the wood unsuitable for sawlogs; and for this reason net growth as calculated from the tables may appear low to those who are more familiar with gross increments.

## Application of the Growth Tables

Take as an example a cordwood (3-9) stand of oak on an average site in the central Lower Peninsula of Michigan. A figure for annual growth in cubic feet for the next 10 years is required. A cruise is run,

using 1/5-acre sample plots. Total-age borings are taken in the 3 to 5 trees of the main stand lying nearest each plot center. From these borings it is calculated that main-stand age averages 40 years. A stand table for the average acre is then prepared. Total stand basal area is computed to be 100 square feet per acre. By use of the oak volumes given in appendix table III, the volume of the stand is found to be 1,000 cubic feet per acre. In accordance with the formula given on page 17, the computation of growth is then made in seven steps, by use of cubic-foot factors read from the oak growth table. The growth computation is illustrated in table 9.

Table 9. -- Sample Form for Calculating Growth by Means of Growth Factors

Cover type: oak

Age: 40 yrs.
Volume (v): 1,000 cu.ft.
Basal area (b): 100 sq.ft.
Growth table: appendix table VII

Factor A: 0.388
Factor B: 0.00274
Factor C: 4.20
Factor D: 0.0014

| | | | |
|---|---|---|---|
| 1. Multiply volume by factor A... | $vA = 1{,}000 \times 0.388 =$ ..... | 388 | |
| 2. Multiply volume by basal area; multiply result by factor B. | $vbB = 1{,}000 \times 100 \times 0.00274 =$ | 274 | |
| 3. Subtract[1] (2) from (1)..... | ..... | | 114 |
| 4. Multiply basal area by factor C..... | $bC = 100 \times 4.20 =$ ..... | 420 | |
| 5. Square basal area and multiply by factor D..... | $b^2D = 10{,}000 \times 0.0014 =$ ..... | 14 | |
| 6. Subtract[1] (5) from (4)..... | ..... | | 406 |
| 7. Add[1] (3) and (6)..... | ..... | | 520 |

Growth per acre in 10 yrs.: 520 cu.ft. Growth per acre per yr.: 52 cu.ft.

[1] All additions and subtractions are made algebraically. That is, when factor A is negative, (1) and (2) are added and their sum given a negative sign. When factor D is negative, (4) and (5) are added and their sum given a positive sign. Similarly, when (3) is negative and smaller than (6) it is subtracted from (6) and the difference given a positive sign. When (3) is negative and larger than (6) the latter is subtracted from the former and the difference given a negative sign; this, of course, would mean that the stand is retrogressing.

It will be noticed that at the foot of each growth table are shown factors for the four size classes of stands recognized in the Forest Survey. These factors may conveniently be used to obtain some idea of current growth in stands for which exact main-stand age is unknown. Where a board-foot prediction is required for a 0-5 stand which contains considerable sawlog volume -- say, more than 6 board feet per square foot of basal area -- the 9-15 factors should generally be used, since the sawlog portion of such a stand usually resembles that of a poorly stocked 9-15 stand.

If an estimate of growth is desired for a second 10-year period it is necessary to calculate the stand basal area expected 10 years hence. This can be done by use of a basal-area factor. Appendix tables XIII and XIV show such factors for each cover type, unit of volume, and age. The basal area 10 years hence is obtained by multiplying the difference[9/] between items (4) and (5) in the above illustration by this factor. For example, in the case of the oak stand illustrated in table 9 the basal-area factor for cubic feet at age 40, as read from appendix table XIV, is 0.2602. The difference between items (4) and (5) in the growth calculation is 406. Multiplying this difference by the factor 0.2602 gives 105.6 square feet, which is the expected basal area 10 years hence. The basal area thus obtained -- together with the computed volume 10 years hence of 1,520 cubic feet (1,000 + 520) -- can then be used in conjunction with oak growth factors for age 50 in order to estimate growth for the second decade.

In the above example it was assumed that the basic volume table used was applicable to the stand in question. If a local volume table is available for any stand and if this table is found to underrun or overrun the basic table by a considerable margin, the following procedure is recommended:

1. Compute growth as shown in the example, using the volume calculated by means of the basic volume table.

2. Express the growth as a percentage of this calculated volume.

3. Apply the growth percentage so obtained to the actual present volume of the stand.

## Yield Tables

From the basic relations determined through study of undisturbed sample plots yield tables were prepared showing the development of stands in volume, assuming good density and an average trend in the ratio of

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9/This is simply the straight difference between the two items, regardless of signs. It will be equal to item (6) in the above illustration in all cases, except when factor D is negative.

volume to basal area. The yield tables, while they do not allow for variations in merchantability index, are useful in many types of growth calculation and have the outstanding advantage of simplicity. They appear here as appendix tables XV through XXIII. The tables differ from normal-yield tables in two important particulars:

1. They conform to utilization standards of the Forest Survey[10], which correspond to current cutting practice of good operators in the Lake States rather than to the very complete utilization assumed in most normal-yield tables.

2. They make allowance for woods and mill cull.

Since the yield tables are derived from the same basic data as are the growth tables, the standards and definitions given for the growth tables apply to the yield tables as well. Some additional points require explanation.

Average diameter is that of main-stand trees only. Where average main-stand diameter is required but not directly available, it may be approximated by computing the average diameter of all trees belonging to key diameter classes, which are shown in table 10.

Table 10. -- Key Diameter Classes for Determining Main-Stand Diameter

| Size class of stand (inches) | Key diameter classes | Size class of stand (inches) | Key diameter classes |
|---|---|---|---|
| | Inches | | Inches |
| 0-5 | 2, 4, 6 | 9-15 | 6+ |
| 3-9 | 4+ | 15+ | 8+ |

For some of the cover types three broad site classes are recognized, the central one representing approximately average conditions for the region. For types which are to be found in the even-aged condition, such as the pines and aspen, the relation between the age and the average height of dominant trees has been used as an index of site quality. (See appendix table XXVII.) For other types the basic site index is the relation between the age and the average diameter of the main stand in undisturbed timber. In the case of the bottomland-hardwood type, the influence of site quality is partly accounted for by the use of two subdivisions: southern type, which includes stands running largely to elms and soft maples, and northern type, in which the associated species is black ash rather than maple.

[10] The tables are based on the volumes given in appendix tables II and III.

Localities typical of the three site classes recognized for upland hardwoods are as follows:

1. Northern hardwoods: good site, Lower Peninsula of Michigan and eastern Wisconsin; average site, Upper Peninsula of Michigan, western Wisconsin, and "Big Woods" area of Minnesota; poor site, central Minnesota and sandy areas in Michigan and Wisconsin.

2. Oak: good site, southern Lower Peninsula of Michigan and east-central Wisconsin, especially coves and terraces; average site, southeastern Minnesota, southwestern Wisconsin, and central Lower Peninsula of Michigan; poor site, sandy areas and the prairie border.

Use of Yield Tables

As an example of the use of the yield tables in predicting current growth take a stand of aspen on spruce-balsam land (average site) in northern Wisconsin. Main-stand age averages about 60 years and net volume per acre about 1,750 board feet, Scribner. Reference to the aspen yield table (appendix table XX) shows that a fully stocked stand of age 60 on an average site contains 3,500 board feet, Scribner, per acre and in 10 years will grow

$$5,750 - 3,500 = 2,250 \text{ board feet per acre.}$$

The degree of stocking of the stand in question, in terms of the yield-table volume for age 60, is

$$\frac{1,750}{3,500} = 50 \text{ percent.}$$

The conventional method of predicting growth from a yield table assumes that the growth of an understocked stand bears the same relation to yield-table growth as its volume bears to the yield-table volume. Thus the growth of this stand in 10 years would be assumed to be 50 percent of 2,250, or 1,125, board feet per acre. However, on the basis of the studies of approach toward normality mentioned on page 16 it is possible to improve upon this estimate. Table 11 presents a convenient means of doing this. It shows, for example, that growth in the aspen stand under consideration will be, not 50 percent of the yield-table growth, but actually 67.5 percent, or 1,519 board feet, Scribner, per acre in 10 years.

Predictions for periods longer than 10 years can be made by the use of table 11 in 10-year steps, a new value for degree of stocking being used at each step. For the second 10-year period, in the example, the degree of stocking would be

$$\frac{1,750 + 1,519}{5,750} = 0.57, \text{ or } 57 \text{ percent.}$$

A new percentage value of 74.0 is obtained by interpolation from table 11, for 57 percent stocking, and the growth for the second 10-year period is found to be

$$(6,400 - 5,750) \times 0.74 = 481 \text{ board feet.}$$

Table 11. -- Growth of Understocked Stands in Percentage of Normal Growth (10-year Period), by Forest Cover Type and Density

| Present stocking (percent of normal) | Jack pine | Aspen and red pine | Oak and bottomland hardwoods | White pine | Northern hardwoods and black spruce | Balsam fir |
|---|---|---|---|---|---|---|
| | Percent | Percent | Percent | Percent | Percent | Percent |
| 10 | 15.4 | 16.3 | 17.2 | 18.1 | 19.0 | 19.9 |
| 20 | 29.6 | 31.2 | 32.8 | 34.4 | 36.0 | 37.6 |
| 30 | 42.6 | 44.7 | 46.8 | 48.9 | 51.0 | 53.1 |
| 40 | 54.4 | 56.8 | 59.2 | 61.6 | 64.0 | 66.4 |
| 50 | 65.0 | 67.5 | 70.0 | 72.5 | 75.0 | 77.5 |
| 60 | 74.4 | 76.8 | 79.2 | 81.6 | 84.0 | 86.4 |
| 70 | 82.6 | 84.7 | 86.8 | 88.9 | 91.0 | 93.1 |
| 80 | 89.6 | 91.2 | 92.8 | 94.4 | 96.0 | 97.6 |
| 90 | 95.4 | 96.3 | 97.2 | 98.1 | 99.0 | 99.9 |
| 100 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

It has here been assumed that the basic volume table (appendix table II) is applicable to the stand under consideration. If this is not the case an allowance can be made as suggested on page 20.

The growth estimate obtained from the yield table does not allow for variation in the merchantability index, which is an important consideration in stands not even-aged. It does, however, allow for approach toward normality and is, therefore, sufficiently exact for many purposes.

In addition to their use in predicting growth for short periods in the future, the yield tables can be employed in estimating mean annual growth and final yields for any assumed rotation. These estimates are made as would be done in using any normal-yield table.

# APPENDIX A

Merchantability Standards

Merchantable Heights

Volume Tables

## Units of Volume and Standards of Merchantability

Board Feet. Board-foot volume is the net volume of trees 9 inches and larger in d.b.h. Top diameters are variable, the minimum being 8 inches inside bark for hardwoods, 6 inches inside bark for conifers and aspen. Trees 9 to 17 inches in d.b.h. are not considered merchantable unless they will produce at least an 8-foot log of high quality or a 16-foot log of low quality; trees 17 inches or more in diameter are not considered merchantable unless they will produce at least one high-quality 12-foot log or two low-quality 16-foot logs. Stump height is 1 foot for trees up to 18 inches in d.b.h., 2 feet for larger trees.

Cubic Feet. Cubic-foot volume is the gross volume, excluding bark, of trees 5 inches and larger in d.b.h., to a top diameter of 4 inches inside bark. For hardwood species, cubic volume also includes the volume of tops and limbs suitable for cordwood, to a diameter of 4 inches inside bark. Stump height is the same as for board-foot volume.

Cords. Cord volume includes the same material for which cubic-foot volume is computed, piled with the bark on, in standard cords 4' x 4' x 8'.

Cull. Board-foot volume represents the scale of merchantable sawlogs only: cull trees, woods cull, and mill cull are deducted.

> Cull trees are those which do not come up to the standards of merchantability for board-foot volume, and which show no prospects of becoming merchantable for sawlogs.
>
> Woods cull consists of long butts and other sections of merchantable sawlog trees commonly left in the woods (but not cull sections lying above the merchantable height).
>
> Mill cull consists of losses expected in milling due to sweep, rot, shake, or other defects.

Table I. -- Average Merchantable Heights and Volumes[1] of Conifers and Hardwoods[2] in the Lake States, by D. B. H. Class

| Diameter breast high (inches) | Conifers | | | Hardwoods | | |
|---|---|---|---|---|---|---|
| | Merchantable height for sawlogs | Volume per tree | | Merchantable height for sawlogs | Volume per tree | |
| | Feet | Bd.ft.[3] | Cu.ft. | Feet | Bd.ft.[3] | Cu.ft. |
| 6 | ..... | ..... | 2 | ..... | ..... | 2 |
| 7 | ..... | ..... | 4 | ..... | ..... | 4 |
| 8 | ..... | ..... | 6 | ..... | ..... | 6 |
| 9 | ..... | ..... | 9 | ..... | ..... | 9 |
| 10 | 23 | 27 | 12 | 8 | 13 | 12 |
| 11 | 27 | 38 | 15 | 16 | 27 | 16 |
| 12 | 30 | 52 | 18 | 20 | 43 | 20 |
| 13 | 32 | 69 | 22 | 23 | 59 | 25 |
| 14 | 35 | 89 | 26 | 26 | 78 | 30 |
| 15 | 37 | 112 | 30 | 28 | 99 | 35 |
| 16 | 39 | 139 | 36 | 30 | 122 | 41 |
| 17 | 41 | 168 | 41 | 31 | 147 | 47 |
| 18 | 43 | 199 | 47 | 33 | 173 | 54 |
| 19 | 45 | 234 | 53 | 34 | 203 | 62 |
| 20 | 46 | 270 | 60 | 35 | 234 | 70 |
| 21 | 47 | 309 | 68 | 36 | 268 | 78 |
| 22 | 49 | 350 | 76 | 37 | 303 | 88 |
| 23 | 50 | 394 | 84 | 38 | 342 | 98 |
| 24 | 51 | 440 | 93 | 38 | 381 | 108 |
| 25 | 52 | 485 | 103 | 39 | 422 | 118 |
| 26 | 53 | 535 | 112 | 39 | 463 | 128 |

[1] Low merchantable heights and board-foot volumes for trees 10 to 15 inches in d.b.h. are due to the fact that some of the trees, although not culls, are still too small to contain merchantable sawlogs.

[2] Aspen is included in the board-foot volume of conifers and in the cubic-foot volume of hardwoods.

[3] Scribner rule. Board-foot volumes are net -- that is, woods and mill cull to the amount of 15 percent for conifers and 20 percent for hardwoods has been deducted from the gross volumes.

Table II. -- Basic Board-Foot Volume Tables Used in Preparing Growth and Yield Tables

| Diameter breast high (inches) | Volume per tree, in board feet, by forest cover type and size class[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jack pine | | Red pine | | White pine | | Northern hardwoods | | Oak |
| | 0-9 | 9+ | 0-9 | 9+ | 0-9 | 9+ | 0-9 | 9+ | 0-9 |
| 10 | 10 | 17 | 18 | 28 | 19 | 20 | 10 | 14 | 5 |
| 12 | 36 | 41 | 43 | 54 | 43 | 49 | 35 | 43 | 24 |
| 14 | 70 | 74 | 77 | 96 | 71 | 90 | 64 | 78 | 47 |
| 16 | 110 | 111 | 120 | 155 | 105 | 145 | 100 | 122 | 77 |
| 18 | 153 | 154 | 183 | 228 | 145 | 214 | 143 | 174 | 113 |
| 20 | 204 | 206 | 258 | 317 | 195 | 297 | 196 | 233 | 156 |
| 22 | 262 | 265 | 343 | 420 | 252 | 394 | 256 | 300 | 207 |
| 24 | 324 | 327 | 440 | 532 | 316 | 498 | 322 | 371 | 264 |
| 26 | ..... | ..... | ..... | ..... | ..... | 617 | ..... | 451 | ..... |
| 28 | ..... | ..... | ..... | ..... | ..... | 743 | ..... | 535 | ..... |
| 30 | ..... | ..... | ..... | ..... | ..... | 875 | ..... | 619 | ..... |
| | Aspen | | Balsam fir | | Black spruce | | Bottomland hardwoods | | Oak |
| | 0-9 | 9+ | 0-9 | 9+ | 0-9 | 9+ | 0-9 | 9+ | 9+ |
| 10 | 22 | 22 | 19 | 21 | 23 | 24 | 8 | 12 | 12 |
| 12 | 46 | 53 | 44 | 52 | 50 | 56 | 29 | 38 | 45 |
| 14 | 74 | 92 | 76 | 92 | 84 | 100 | 55 | 73 | 87 |
| 16 | 107 | 136 | 122 | 139 | 126 | 157 | 88 | 118 | 131 |
| 18 | 146 | 185 | 176 | 194 | 176 | 224 | 126 | 172 | 180 |
| 20 | 194 | 239 | 242 | 256 | 238 | 305 | 174 | 235 | 233 |
| 22 | 249 | 297 | 313 | 324 | 309 | 392 | 227 | 306 | 293 |
| 24 | 310 | 357 | 390 | 397 | 392 | 484 | 288 | 382 | 354 |
| 26 | ..... | 426 | ..... | 481 | ..... | ..... | ..... | 468 | 426 |
| 28 | ..... | 500 | ..... | 568 | ..... | ..... | ..... | 559 | 502 |
| 30 | ..... | 573 | ..... | 656 | ..... | ..... | ..... | 650 | 576 |

[1]/Size class 0-9 includes 0-5 and 3-9 stands; class 9+ includes 9-15 and 15+ stands.

Table III. -- Basic Cubic-Foot Volume Tables Used in Preparing Growth and Yield Tables

| Diameter breast high (inches) | Volume per tree, in cubic feet, by forest cover type and size class[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jack pine | | Red pine | | White pine | | Northern hardwoods | | Oak |
| | 0-9 | 9+ | 0-9 | 9+ | 0-9 | 9+ | 0-9 | 9+ | 0-9 |
| 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 8 | 5 | 5 | 5 | 6 | 5 | 6 | 5 | 6 | 5 |
| 10 | 10 | 10 | 10 | 12 | 10 | 11 | 10 | 11 | 9 |
| 12 | 16 | 17 | 17 | 20 | 16 | 19 | 17 | 18 | 15 |
| 14 | 24 | 26 | 26 | 30 | 24 | 28 | 25 | 27 | 22 |
| 16 | 33 | 36 | 36 | 42 | 33 | 40 | 35 | 38 | 30 |
| 18 | 43 | 48 | 47 | 57 | 44 | 53 | 47 | 50 | 39 |
| 20 | 55 | 62 | 60 | 74 | 55 | 69 | 60 | 65 | 49 |
| 22 | 67 | 77 | 74 | 92 | 68 | 86 | 74 | 80 | 59 |
| 24 | 80 | 94 | 90 | 113 | 81 | 105 | 89 | 98 | 70 |
| 26 | ..... | ..... | ..... | ..... | ..... | 126 | ..... | 116 | ..... |
| 28 | ..... | ..... | ..... | ..... | ..... | 147 | ..... | 135 | ..... |
| 30 | ..... | ..... | ..... | ..... | ..... | 169 | ..... | 154 | ..... |
| | Aspen | | Balsam fir | | Black spruce | | Bottomland hardwoods | | Oak |
| | 0-9 | 9+ | 0-9 | 9+ | 0-9 | 9+ | 0-9 | 9+ | 9+ |
| 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 8 | 6 | 6 | 5 | 5 | 5 | 6 | 5 | 6 | 6 |
| 10 | 11 | 11 | 10 | 10 | 9 | 11 | 10 | 11 | 11 |
| 12 | 18 | 19 | 17 | 17 | 15 | 18 | 16 | 18 | 18 |
| 14 | 26 | 28 | 26 | 26 | 23 | 27 | 24 | 27 | 26 |
| 16 | 36 | 39 | 36 | 36 | 31 | 37 | 33 | 38 | 36 |
| 18 | 48 | 51 | 48 | 48 | 41 | 50 | 43 | 50 | 48 |
| 20 | 62 | 66 | 61 | 62 | 51 | 64 | 54 | 65 | 61 |
| 22 | 78 | 82 | 76 | 77 | 62 | 79 | 66 | 80 | 76 |
| 24 | 95 | 99 | 93 | 94 | 74 | 96 | 79 | 97 | 92 |
| 26 | ..... | 118 | ..... | 112 | ..... | ..... | ..... | 116 | 109 |
| 28 | ..... | 136 | ..... | 130 | ..... | ..... | ..... | 134 | 127 |
| 30 | ..... | 156 | ..... | 149 | ..... | ..... | ..... | 153 | 145 |

[1] Size class 0-9 includes 0-5 and 3-9 stands; class 9+ includes 9-15 and 15+ stands.

# APPENDIX B

Growth Tables

Yield Tables

Growth-Percent Tables

Site-Index Tables

Bark Factors

Table IV. -- Ten-Year Growth Factors for Stands of the Jack Pine Cover Type in the Lake States

Average Site

| Main-stand age (years) or size class (inches) | For board feet (Scribner) | | | | For cubic feet | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| 20 | 0.998 | 0.00607 | 2.24 | 0.0008 | 0.933 | 0.00476 | 3.74 | 0.0013 |
| 30 | 1.100 | 0.00531 | 3.99 | 0.0004 | 0.456 | 0.00179 | 2.25 | 0.0002 |
| 40 | 0.549 | 0.00296 | 5.84 | 0.0001 | 0.224 | 0.00089 | 1.66 | 0.0000 |
| 50 | 0.227 | 0.00170 | 7.11 | -0.0002 | 0.107 | 0.00048 | 1.31 | -0.0001 |
| 60 | 0.119 | 0.00116 | 7.84 | -0.0008 | 0.037 | 0.00026 | 1.05 | -0.0001 |
| 70 | 0.001 | 0.00072 | 7.82 | -0.0014 | -0.027 | 0.00006 | 0.81 | -0.0002 |
| 80 | -0.087 | 0.00036 | 7.18 | -0.0022 | -0.049 | 0.00016 | 0.62 | -0.0002 |
| 0-5 | 1.030 | 0.00601 | 2.46 | 0.0008 | 0.900 | 0.00432 | 3.40 | 0.0009 |
| 3-9 | 0.399 | 0.00236 | 6.36 | -0.0001 | 0.172 | 0.00070 | 1.49 | 0.0000 |
| 9-15 | 0.036 | 0.00080 | 7.90 | -0.0013 | -0.014 | 0.00010 | 0.86 | -0.0001 |

Table V. -- Ten-Year Growth Factors for Stands of the White Pine Cover Type in the Lake States

Average Site

| Main-stand age (years) or size class (inches) | For board feet (Scribner) | | | | For cubic feet | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| 20 | 1.956 | 0.01293 | 2.66 | 0.0035 | 3.407 | 0.02425 | 8.26 | 0.0110 |
| 30 | 2.156 | 0.01225 | 7.41 | 0.0040 | 1.023 | 0.00542 | 7.53 | 0.0040 |
| 40 | 1.593 | 0.00828 | 16.63 | 0.0049 | 0.452 | 0.00204 | 5.21 | 0.0016 |
| 50 | 0.677 | 0.00317 | 16.68 | 0.0031 | 0.232 | 0.00094 | 3.12 | 0.0006 |
| 60 | 0.359 | 0.00159 | 13.81 | 0.0016 | 0.145 | 0.00055 | 2.10 | 0.0002 |
| 70 | 0.234 | 0.00100 | 11.71 | 0.0009 | 0.098 | 0.00036 | 1.55 | 0.0001 |
| 80 | 0.170 | 0.00071 | 10.21 | 0.0006 | 0.065 | 0.00025 | 1.22 | 0.0001 |
| 90 | 0.129 | 0.00053 | 8.85 | 0.0005 | 0.052 | 0.00019 | 0.93 | 0.0000 |
| 100 | 0.094 | 0.00039 | 7.50 | 0.0002 | 0.040 | 0.00014 | 0.68 | 0.0000 |
| 110 | 0.073 | 0.00030 | 6.26 | 0.0001 | 0.034 | 0.00010 | 0.50 | 0.0000 |
| 120 | 0.055 | 0.00022 | 5.06 | 0.0001 | 0.026 | 0.00008 | 0.39 | 0.0000 |
| 130 | 0.042 | 0.00017 | 3.99 | 0.0001 | 0.022 | 0.00007 | 0.28 | 0.0000 |
| 140 | 0.028 | 0.00011 | 2.79 | 0.0003 | 0.012 | 0.00004 | 0.23 | 0.0000 |
| 0-5 | 2.138 | 0.01305 | 4.33 | 0.0035 | 1.828 | 0.01064 | 8.17 | 0.0066 |
| 3-9 | 1.020 | 0.00514 | 18.30 | 0.0042 | 0.313 | 0.00134 | 4.03 | 0.0009 |
| 9-15 | 0.200 | 0.00084 | 10.93 | 0.0007 | 0.079 | 0.00030 | 1.35 | 0.0001 |
| 15+ | 0.042 | 0.00017 | 3.99 | 0.0001 | 0.022 | 0.00007 | 0.28 | 0.0000 |

Table VI. -- Ten-Year Growth Factors for Stands of the Northern Hardwood Cover Type in the Lake States

Average Site

| Main-stand age (years) or size class (inches) | For board feet (Scribner) | | | | For cubic feet | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| 20 | 0.670 | 0.00565 | 1.06 | 0.0019 | 2.973 | 0.03228 | 6.12 | 0.0110 |
| 30 | 1.087 | 0.00685 | 1.31 | 0.0014 | 0.908 | 0.00742 | 4.66 | 0.0049 |
| 40 | 1.956 | 0.01006 | 2.25 | 0.0016 | 0.553 | 0.00347 | 2.92 | 0.0021 |
| 50 | 1.536 | 0.00725 | 3.53 | 0.0018 | 0.393 | 0.00215 | 2.22 | 0.0011 |
| 60 | 0.973 | 0.00443 | 4.76 | 0.0018 | 0.284 | 0.00145 | 1.87 | 0.0007 |
| 70 | 0.551 | 0.00254 | 5.56 | 0.0017 | 0.204 | 0.00102 | 1.69 | 0.0005 |
| 80 | 0.350 | 0.00166 | 5.98 | 0.0015 | 0.148 | 0.00074 | 1.56 | 0.0004 |
| 90 | 0.243 | 0.00119 | 6.26 | 0.0014 | 0.111 | 0.00057 | 1.51 | 0.0003 |
| 100 | 0.180 | 0.00091 | 6.37 | 0.0012 | 0.088 | 0.00046 | 1.45 | 0.0003 |
| 110 | 0.141 | 0.00073 | 6.45 | 0.0012 | 0.070 | 0.00038 | 1.39 | 0.0003 |
| 120 | 0.110 | 0.00060 | 6.39 | 0.0010 | 0.057 | 0.00032 | 1.35 | 0.0002 |
| 130 | 0.083 | 0.00049 | 6.45 | 0.0009 | 0.049 | 0.00028 | 1.30 | 0.0002 |
| 140 | 0.060 | 0.00040 | 6.50 | 0.0008 | 0.040 | 0.00024 | 1.24 | 0.0002 |
| 150 | 0.039 | 0.00033 | 6.56 | 0.0007 | 0.033 | 0.00021 | 1.17 | 0.0001 |
| 160 | 0.024 | 0.00027 | 6.58 | 0.0007 | 0.026 | 0.00018 | 1.10 | 0.0001 |
| 170 | 0.011 | 0.00023 | 6.47 | 0.0006 | 0.021 | 0.00015 | 1.03 | 0.0001 |
| 180 | 0.002 | 0.00019 | 6.33 | 0.0005 | 0.018 | 0.00013 | 0.96 | 0.0001 |
| 190 | -0.005 | 0.00016 | 6.07 | 0.0004 | 0.015 | 0.00011 | 0.88 | 0.0001 |
| 200 | -0.010 | 0.00013 | 5.69 | 0.0003 | 0.012 | 0.00010 | 0.80 | 0.0001 |
| 210 | -0.010 | 0.00011 | 5.11 | 0.0003 | 0.011 | 0.00009 | 0.72 | 0.0000 |
| 220 | -0.007 | 0.00010 | 4.32 | 0.0002 | 0.009 | 0.00008 | 0.64 | 0.0000 |
| 230 | -0.001 | 0.00009 | 3.43 | 0.0001 | 0.006 | 0.00006 | 0.56 | 0.0000 |
| 240 | 0.004 | 0.00007 | 2.42 | 0.0001 | 0.006 | 0.00005 | 0.48 | 0.0000 |
| 0-5 | 0.822 | 0.00570 | 1.08 | 0.0013 | 1.743 | 0.01577 | 6.43 | 0.0129 |
| 3-9 | 1.803 | 0.00865 | 3.14 | 0.0017 | 0.318 | 0.00247 | 2.34 | 0.0013 |
| 9-15 | 0.138 | 0.00071 | 6.43 | 0.0016 | 0.068 | 0.00037 | 1.38 | 0.0003 |
| 15+ | 0.013 | 0.00023 | 6.47 | 0.0006 | 0.022 | 0.00016 | 1.05 | 0.0001 |

Table VII. -- Ten-Year Growth Factors for Stands of the Oak Cover Type in the Lake States

Average Site

| Main-stand age (years) or size class (inches) | For board feet (Scribner) | | | | For cubic feet | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| 20 | 1.683 | 0.01617 | 2.30 | 0.0043 | 1.995 | 0.02054 | 6.14 | 0.0115 |
| 30 | 1.377 | 0.01029 | 3.53 | 0.0025 | 1.014 | 0.00717 | 5.21 | 0.0038 |
| 40 | 2.004 | 0.01161 | 7.08 | 0.0023 | 0.388 | 0.00274 | 4.20 | 0.0014 |
| 50 | 1.446 | 0.00777 | 11.89 | 0.0021 | 0.137 | 0.00138 | 4.01 | 0.0007 |
| 60 | 0.513 | 0.00321 | 14.23 | 0.0014 | 0.029 | 0.00082 | 3.91 | 0.0004 |
| 70 | 0.168 | 0.00153 | 14.36 | 0.0007 | -0.027 | 0.00052 | 3.67 | 0.0002 |
| 80 | 0.023 | 0.00080 | 13.40 | 0.0001 | -0.059 | 0.00032 | 3.34 | 0.0001 |
| 90 | -0.036 | 0.00046 | 11.99 | -0.0003 | -0.073 | 0.00019 | 2.97 | -0.0001 |
| 100 | -0.064 | 0.00024 | 10.19 | -0.0007 | -0.078 | 0.00010 | 2.55 | -0.0002 |
| 110 | -0.079 | 0.00009 | 8.30 | -0.0009 | -0.081 | 0.00003 | 2.09 | -0.0002 |
| 120 | -0.076 | 0.00005 | 6.32 | -0.0010 | -0.082 | 0.00006 | 1.64 | -0.0003 |
| 0-5 | 1.683 | 0.01617 | 2.30 | 0.0043 | 1.995 | 0.02054 | 6.14 | 0.0115 |
| 3-9 | 2.045 | 0.01131 | 8.89 | 0.0022 | 0.296 | 0.00223 | 4.14 | 0.0011 |
| 9-15 | 0.470 | 0.00300 | 14.34 | 0.0013 | 0.020 | 0.00079 | 3.88 | 0.0004 |
| 15+ | -0.055 | 0.00032 | 11.05 | -0.0006 | -0.076 | 0.00013 | 2.70 | -0.0002 |

Table VIII. -- Ten-Year Growth Factors for Stands of the Aspen Cover Type in the Lake States

Good Site -- Index 70 -- Typical of Hardwood Land

| Main-stand age (years) or size class (inches) | For board feet (Scribner) | | | | For cubic feet | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| 20 | 0.511 | 0.00787 | 1.60 | 0.0026 | 2.128 | 0.02739 | 8.29 | 0.0135 |
| 30 | 0.984 | 0.01021 | 3.40 | 0.0029 | 0.644 | 0.00670 | 8.41 | 0.0073 |
| 40 | 2.194 | 0.01612 | 10.67 | 0.0054 | 0.252 | 0.00287 | 7.80 | 0.0040 |
| 50 | 1.399 | 0.01038 | 26.25 | 0.0074 | 0.073 | 0.00144 | 6.79 | 0.0019 |
| 60 | -0.137 | 0.00189 | 30.09 | 0.0033 | -0.050 | 0.00060 | 5.23 | 0.0006 |
| 70 | -0.216 | 0.00057 | 21.04 | -0.0004 | -0.084 | 0.00021 | 3.55 | -0.0001 |
| 80 | -0.208 | 0.00010 | 12.35 | -0.0035 | -0.084 | 0.00021 | 1.84 | -0.0005 |

Average Site -- Index 65 -- Typical of Spruce-Balsam Land

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 20 | 0.544 | 0.00800 | 1.36 | 0.0023 | 2.270 | 0.03054 | 7.01 | 0.0119 |
| 30 | 0.553 | 0.00732 | 2.41 | 0.0022 | 0.746 | 0.00783 | 7.76 | 0.0072 |
| 40 | 1.689 | 0.01326 | 6.39 | 0.0033 | 0.300 | 0.00329 | 7.27 | 0.0037 |
| 50 | 1.890 | 0.01327 | 18.04 | 0.0041 | 0.092 | 0.00160 | 6.30 | 0.0015 |
| 60 | 0.220 | 0.00353 | 25.00 | 0.0020 | -0.032 | 0.00072 | 4.99 | 0.0002 |
| 70 | -0.207 | 0.00078 | 19.82 | -0.0033 | -0.117 | 0.00014 | 3.46 | -0.0006 |
| 80 | -0.222 | 0.00043 | 11.46 | -0.0071 | -0.100 | 0.00053 | 1.84 | -0.0012 |
| 0-5 | 0.544 | 0.00800 | 1.36 | 0.0023 | 2.270 | 0.03054 | 7.01 | 0.0119 |
| 3-9 | 1.382 | 0.01129 | 4.60 | 0.0026 | 0.400 | 0.00412 | 7.47 | 0.0045 |
| 9-15 | 0.220 | 0.00353 | 25.00 | 0.0020 | -0.032 | 0.00072 | 4.99 | 0.0002 |
| 15+ | -0.222 | 0.00043 | 11.46 | -0.0071 | -0.100 | 0.00053 | 1.84 | -0.0012 |

Poor Site -- Index 60 -- Typical of Pine Land

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 20 | 0.593 | 0.00818 | 1.11 | 0.0020 | 1.914 | 0.02955 | 5.29 | 0.0094 |
| 30 | 0.285 | 0.00542 | 1.71 | 0.0016 | 1.038 | 0.01071 | 6.88 | 0.0066 |
| 40 | 1.167 | 0.01024 | 3.71 | 0.0019 | 0.351 | 0.00390 | 6.66 | 0.0034 |
| 50 | 1.586 | 0.01169 | 9.18 | 0.0021 | 0.117 | 0.00192 | 5.97 | 0.0014 |
| 60 | 0.864 | 0.00680 | 17.13 | -0.0011 | -0.027 | 0.00087 | 4.75 | -0.0003 |
| 70 | -0.195 | 0.00140 | 17.05 | -0.0116 | -0.167 | 0.00038 | 3.27 | -0.0022 |
| 80 | -0.276 | 0.00185 | 10.01 | -0.0202 | -0.147 | 0.00188 | 1.67 | -0.0036 |

Table IX. -- Ten-Year Growth Factors for Stands of the Balsam Fir Cover Type in the Lake States

Average Site

| Main-stand age (years) or size class (inches) | For board feet (Scribner) | | | | For cubic feet | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| 20 | 3.931 | 0.02940 | 4.59 | 0.0057 | 4.564 | 0.03414 | 5.23 | 0.0065 |
| 30 | 1.742 | 0.00947 | 4.56 | 0.0008 | 1.307 | 0.00812 | 5.25 | 0.0010 |
| 40 | 0.793 | 0.00429 | 4.68 | -0.0003 | 0.256 | 0.00173 | 2.54 | -0.0002 |
| 50 | 0.393 | 0.00253 | 5.09 | -0.0012 | 0.080 | 0.00082 | 1.89 | -0.0004 |
| 60 | 0.172 | 0.00161 | 5.64 | -0.0022 | -0.009 | 0.00035 | 1.39 | -0.0005 |
| 70 | 0.009 | 0.00098 | 6.20 | -0.0033 | -0.065 | 0.00009 | 1.02 | -0.0006 |
| 80 | -0.129 | 0.00046 | 6.79 | -0.0049 | -0.040 | 0.00042 | 0.74 | -0.0005 |
| 0-5 | 1.523 | 0.00809 | 4.58 | 0.0005 | 0.884 | 0.00516 | 4.04 | 0.0005 |
| 3-9 | 0.344 | 0.00229 | 5.20 | -0.0014 | 0.040 | 0.00064 | 1.77 | -0.0005 |
| 9-15 | -0.015 | 0.00090 | 6.32 | -0.0036 | -0.057 | 0.00010 | 0.94 | -0.0006 |

Table X. -- Ten-Year Growth Factors for Stands of the Black Spruce Cover Type in the Lake States

Average Site

| Main-stand age (years) or size class (inches) | For board feet (Scribner) | | | | For cubic feet | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| 20 | 2.391 | 0.02912 | 0.77 | 0.0035 | 1.933 | 0.02359 | 0.84 | 0.0038 |
| 30 | 1.263 | 0.01110 | 0.90 | 0.0016 | 2.210 | 0.02082 | 2.13 | 0.0037 |
| 40 | 0.786 | 0.00610 | 1.10 | 0.0010 | 1.419 | 0.01109 | 3.54 | 0.0032 |
| 50 | 0.598 | 0.00417 | 1.28 | 0.0006 | 0.429 | 0.00392 | 3.65 | 0.0017 |
| 60 | 0.711 | 0.00393 | 1.53 | 0.0004 | 0.240 | 0.00229 | 3.43 | 0.0009 |
| 70 | 0.888 | 0.00399 | 1.78 | 0.0003 | 0.136 | 0.00137 | 2.86 | 0.0005 |
| 80 | 1.026 | 0.00399 | 2.01 | 0.0002 | 0.084 | 0.00087 | 2.24 | 0.0003 |
| 90 | 0.710 | 0.00269 | 2.20 | 0.0002 | 0.051 | 0.00060 | 1.84 | 0.0002 |
| 100 | 0.411 | 0.00164 | 2.34 | 0.0001 | 0.023 | 0.00043 | 1.64 | 0.0001 |
| 110 | 0.257 | 0.00111 | 2.54 | 0.0001 | -0.006 | 0.00032 | 1.61 | 0.0001 |
| 120 | 0.158 | 0.00080 | 2.86 | 0.0000 | -0.032 | 0.00024 | 1.66 | 0.0000 |
| 130 | 0.087 | 0.00058 | 3.15 | -0.0001 | -0.055 | 0.00017 | 1.71 | 0.0000 |
| 140 | 0.037 | 0.00043 | 3.39 | -0.0001 | -0.073 | 0.00012 | 1.76 | -0.0001 |
| 150 | -0.002 | 0.00032 | 3.60 | -0.0002 | -0.087 | 0.00008 | 1.79 | -0.0001 |
| 0-5 | 0.650 | 0.00480 | 1.16 | 0.0008 | 0.776 | 0.00662 | 3.69 | 0.0026 |
| 3-9 | 1.006 | 0.00408 | 1.97 | 0.0002 | 0.092 | 0.00094 | 2.32 | 0.0003 |
| 9-15 | 0.158 | 0.00080 | 2.86 | 0.0000 | -0.055 | 0.00017 | 1.71 | 0.0000 |
| 15+ | 0.021 | 0.00038 | 3.48 | -0.0002 | -0.078 | 0.00010 | 1.77 | -0.0001 |

Table XI. -- Ten-Year Growth Factors for Stands of the Bottomland Hardwood Cover Type (Southern) in the Lake States

Average Site

| Main-stand age (years) or size class (inches) | For board feet (Scribner) | | | | For cubic feet | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| 20 | 1.724 | 0.01399 | 8.33 | 0.0110 | 0.850 | 0.00586 | 6.55 | 0.0087 |
| 30 | 0.977 | 0.00588 | 8.55 | 0.0050 | 0.385 | 0.00207 | 3.50 | 0.0021 |
| 40 | 0.755 | 0.00344 | 7.29 | 0.0027 | 0.247 | 0.00119 | 2.55 | 0.0009 |
| 50 | 0.529 | 0.00216 | 6.77 | 0.0017 | 0.171 | 0.00076 | 1.95 | 0.0005 |
| 60 | 0.292 | 0.00128 | 7.01 | 0.0011 | 0.114 | 0.00050 | 1.50 | 0.0002 |
| 70 | 0.130 | 0.00074 | 7.04 | 0.0005 | 0.069 | 0.00031 | 1.11 | 0.0001 |
| 80 | 0.041 | 0.00045 | 6.89 | 0.0000 | 0.035 | 0.00018 | 0.82 | 0.0000 |
| 90 | -0.012 | 0.00029 | 6.82 | -0.0003 | 0.004 | 0.00008 | 0.62 | 0.0000 |
| 100 | -0.050 | 0.00017 | 6.69 | -0.0006 | -0.018 | 0.00003 | 0.49 | 0.0000 |
| 110 | -0.086 | 0.00007 | 6.78 | -0.0010 | -0.019 | 0.00009 | 0.37 | -0.0001 |
| 120 | -0.102 | 0.00007 | 6.81 | -0.0015 | -0.017 | 0.00016 | 0.27 | -0.0001 |
| 130 | -0.107 | 0.00015 | 7.00 | -0.0018 | -0.017 | 0.00022 | 0.20 | -0.0001 |
| 140 | -0.109 | 0.00025 | 7.15 | -0.0024 | -0.017 | 0.00030 | 0.15 | -0.0001 |
| 150 | -0.111 | 0.00035 | 7.28 | -0.0031 | -0.018 | 0.00039 | 0.13 | -0.0001 |
| 0-5 | 2.125 | 0.01876 | 8.38 | 0.0146 | 1.121 | 0.00897 | 8.83 | 0.0154 |
| 3-9 | 0.727 | 0.00325 | 7.16 | 0.0025 | 0.230 | 0.00111 | 2.40 | 0.0008 |
| 9-15 | 0.209 | 0.00100 | 7.00 | 0.0008 | 0.090 | 0.00040 | 1.32 | 0.0002 |
| 15+ | 0.041 | 0.00045 | 6.89 | 0.0000 | 0.035 | 0.00018 | 0.82 | 0.0000 |

Table XII. -- Ten-Year Growth Factors for Stands of the Bottomland Hardwood Cover Type (Northern) in the Lake States

Average Site

| Main-stand age (years) or size class (inches) | For board feet (Scribner) | | | | For cubic feet | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| 20 | 1.325 | 0.01572 | 5.49 | 0.0118 | 1.560 | 0.01452 | 8.57 | 0.0184 |
| 30 | 1.283 | 0.00916 | 6.55 | 0.0060 | 0.598 | 0.00381 | 4.62 | 0.0043 |
| 40 | 0.819 | 0.00456 | 6.37 | 0.0034 | 0.331 | 0.00174 | 2.86 | 0.0015 |
| 50 | 0.610 | 0.00276 | 5.34 | 0.0017 | 0.205 | 0.00101 | 2.10 | 0.0007 |
| 60 | 0.454 | 0.00192 | 5.46 | 0.0012 | 0.154 | 0.00070 | 1.66 | 0.0004 |
| 70 | 0.310 | 0.00137 | 5.59 | 0.0009 | 0.110 | 0.00048 | 1.30 | 0.0002 |
| 80 | 0.205 | 0.00092 | 5.63 | 0.0007 | 0.083 | 0.00035 | 1.03 | 0.0001 |
| 90 | 0.111 | 0.00059 | 5.37 | 0.0006 | 0.056 | 0.00025 | 0.82 | 0.0001 |
| 100 | 0.055 | 0.00041 | 5.16 | 0.0001 | 0.038 | 0.00017 | 0.68 | 0.0000 |
| 110 | 0.015 | 0.00029 | 5.13 | -0.0001 | 0.013 | 0.00010 | 0.57 | 0.0000 |
| 120 | -0.015 | 0.00019 | 5.10 | -0.0002 | -0.006 | 0.00004 | 0.48 | 0.0000 |
| 130 | -0.036 | 0.00013 | 5.05 | -0.0004 | -0.015 | 0.00002 | 0.38 | 0.0000 |
| 140 | -0.061 | 0.00007 | 5.19 | -0.0006 | -0.015 | 0.00005 | 0.32 | 0.0000 |
| 150 | -0.082 | 0.00002 | 5.38 | -0.0008 | -0.014 | 0.00009 | 0.25 | -0.0001 |
| 0-5 | 1.390 | 0.01359 | 5.83 | 0.0092 | 1.089 | 0.00859 | 6.73 | 0.0106 |
| 3-9 | 0.566 | 0.00248 | 5.38 | 0.0015 | 0.187 | 0.00091 | 2.01 | 0.0006 |
| 9-15 | 0.182 | 0.00084 | 5.60 | 0.0006 | 0.078 | 0.00033 | 1.01 | 0.0001 |
| 15+ | 0.045 | 0.00038 | 5.15 | 0.0000 | 0.030 | 0.00015 | 0.63 | 0.0000 |

Table XIII. -- Ten-Year Basal-Area Factors (for Use in Board-Foot Growth Calculations Based on Growth Tables) for Lake States Stands, by Forest Cover Type

| Main-stand age (years) or size class (inches) | Aspen | | | Jack pine, average site | Balsam fir, average site | Oak, average site |
|---|---|---|---|---|---|---|
| | Good site | Average site | Poor site | | | |
| 20 | 0.8929 | 1.0482 | 1.2853 | 0.5149 | 0.3112 | 0.6553 |
| 30 | 0.3674 | 0.5225 | 0.7342 | 0.2606 | 0.2315 | 0.3409 |
| 40 | 0.1082 | 0.1799 | 0.3082 | 0.1725 | 0.2137 | 0.1544 |
| 50 | 0.0415 | 0.0592 | 0.1158 | 0.1401 | 0.1970 | 0.0884 |
| 60 | 0.0344 | 0.0406 | 0.0582 | 0.1262 | 0.1783 | 0.0723 |
| 70 | 0.0475 | 0.0501 | 0.0568 | 0.1255 | 0.1625 | 0.0706 |
| 80 | 0.0797 | 0.0846 | 0.0920 | 0.1353 | 0.1485 | 0.0748 |
| 90 | ..... | ..... | ..... | ..... | ..... | 0.0833 |
| 100 | ..... | ..... | ..... | ..... | ..... | 0.0979 |
| 110 | ..... | ..... | ..... | ..... | ..... | 0.1199 |
| 120 | ..... | ..... | ..... | ..... | ..... | 0.1575 |
| 0-5 | ..... | 1.0482 | ..... | 0.4604 | 0.2258 | 0.6553 |
| 3-9 | ..... | 0.2545 | ..... | 0.1570 | 0.1932 | 0.1211 |
| 9-15 | ..... | 0.0406 | ..... | 0.1246 | 0.1594 | 0.0716 |
| 15+ | ..... | 0.0846 | ..... | ..... | ..... | 0.0904 |

Table XIII. -- Ten-Year Basal-Area Factors (for Use in Board-Foot Growth Calculations Based on Growth Tables) for Lake States Stands, by Forest Cover Type -- Continued

| Main-stand age (years) or size class (inches) | White pine, average site | Bottomland hardwoods | | Black spruce, average site | Northern hardwoods, average site |
|---|---|---|---|---|---|
| | | Southern type | Northern type | | |
| 20 | 0.5882 | 0.1739 | 0.3023 | 2.8736 | 1.3550 |
| 30 | 0.1664 | 0.1412 | 0.1990 | 1.6863 | 0.9709 |
| 40 | 0.0681 | 0.1560 | 0.1860 | 1.1601 | 0.5313 |
| 50 | 0.0649 | 0.1616 | 0.2092 | 0.8913 | 0.3244 |
| 60 | 0.0763 | 0.1511 | 0.1984 | 0.7087 | 0.2339 |
| 70 | 0.0885 | 0.1464 | 0.1896 | 0.5590 | 0.1970 |
| 80 | 0.1007 | 0.1453 | 0.1856 | 0.5063 | 0.1809 |
| 90 | 0.1155 | 0.1462 | 0.1905 | 0.4675 | 0.1717 |
| 100 | 0.1352 | 0.1488 | 0.1950 | 0.4352 | 0.1677 |
| 110 | 0.1614 | 0.1464 | 0.1947 | 0.3975 | 0.1648 |
| 120 | 0.1994 | 0.1456 | 0.1955 | 0.3501 | 0.1655 |
| 130 | 0.2525 | 0.1414 | 0.1975 | 0.3179 | 0.1634 |
| 140 | 0.3595 | 0.1381 | 0.1920 | 0.2946 | 0.1615 |
| 150 | ..... | 0.1353 | 0.1849 | 0.2776 | 0.1592 |
| 160 | ..... | ..... | ..... | ..... | 0.1581 |
| 170 | ..... | ..... | ..... | ..... | 0.1601 |
| 180 | ..... | ..... | ..... | ..... | 0.1630 |
| 190 | ..... | ..... | ..... | ..... | 0.1694 |
| 200 | ..... | ..... | ..... | ..... | 0.1802 |
| 210 | ..... | ..... | ..... | ..... | 0.2002 |
| 220 | ..... | ..... | ..... | ..... | 0.2361 |
| 230 | ..... | ..... | ..... | ..... | 0.2974 |
| 240 | ..... | ..... | ..... | ..... | 0.4203 |
| 0-5 | 0.3114 | 0.1898 | 0.2560 | 1.0520 | 1.2900 |
| 3-9 | 0.0603 | 0.1577 | 0.2055 | 0.5112 | 0.3675 |
| 9-15 | 0.0935 | 0.1495 | 0.1858 | 0.3501 | 0.1652 |
| 15+ | 0.2525 | 0.1453 | 0.1945 | 0.2874 | 0.1600 |

Table XIV. -- Ten-Year Basal-Area Factors (for Use in Cubic-Foot Growth Calculations Based on Growth Tables) for Lake States Stands, by Forest Cover Type

| Main-stand age (years) or size class (inches) | Aspen | | | Jack pine, average site | Balsam fir average site | Oak, average site |
|---|---|---|---|---|---|---|
| | Good site | Average site | Poor site | | | |
| 20 | 0.1721 | 0.2030 | 0.2698 | 0.3088 | 0.2732 | 0.2476 |
| 30 | 0.1483 | 0.1623 | 0.1820 | 0.4625 | 0.2013 | 0.2311 |
| 40 | 0.1481 | 0.1581 | 0.1715 | 0.6064 | 0.3940 | 0.2602 |
| 50 | 0.1604 | 0.1693 | 0.1781 | 0.7587 | 0.5316 | 0.2624 |
| 60 | 0.1979 | 0.2019 | 0.2098 | 0.9443 | 0.7215 | 0.2633 |
| 70 | 0.2814 | 0.2884 | 0.2967 | 1.2107 | 0.9862 | 0.2763 |
| 80 | 0.5348 | 0.5280 | 0.5525 | 1.5649 | 1.3699 | 0.3000 |
| 90 | ..... | ..... | ..... | ..... | ..... | 0.3368 |
| 100 | ..... | ..... | ..... | ..... | ..... | 0.3918 |
| 110 | ..... | ..... | ..... | ..... | ..... | 0.4764 |
| 120 | ..... | ..... | ..... | ..... | ..... | 0.6083 |
| 0-5 | ..... | 0.2030 | ..... | 0.3320 | 0.2559 | 0.2476 |
| 3-9 | ..... | 0.1568 | ..... | 0.6689 | 0.5685 | 0.2608 |
| 9-15 | ..... | 0.2019 | ..... | 1.1494 | 1.0811 | 0.2648 |
| 15+ | ..... | 0.5280 | ..... | ..... | ..... | 0.3697 |

Table XIV. -- Ten-Year Basal-Area Factors (for Use in Cubic-Foot Growth Calculations Based on Growth Tables) for Lake States Stands, by Forest Cover Type -- Continued

| Main-stand age (years) or size class (inches) | White pine, average site | Bottomland hardwoods | | Black spruce, average site | Northern hardwoods, average site |
|---|---|---|---|---|---|
| | | Southern type | Northern type | | |
| 20 | 0.1893 | 0.2212 | 0.1936 | 2.6455 | 0.2337 |
| 30 | 0.1636 | 0.3453 | 0.2820 | 0.7128 | 0.2724 |
| 40 | 0.2175 | 0.4462 | 0.4134 | 0.3618 | 0.4089 |
| 50 | 0.3471 | 0.5624 | 0.5320 | 0.3150 | 0.5154 |
| 60 | 0.5023 | 0.7092 | 0.6510 | 0.3165 | 0.5942 |
| 70 | 0.6684 | 0.9285 | 0.8163 | 0.3700 | 0.6494 |
| 80 | 0.8432 | 1.2270 | 1.0163 | 0.4647 | 0.6935 |
| 90 | 1.0941 | 1.6051 | 1.2500 | 0.5583 | 0.7093 |
| 100 | 1.4925 | 2.0450 | 1.4750 | 0.6215 | 0.7375 |
| 110 | 2.0284 | 2.6882 | 1.7668 | 0.6258 | 0.7640 |
| 120 | 2.5720 | 3.6232 | 2.0790 | 0.6020 | 0.7800 |
| 130 | 3.5461 | 5.0500 | 2.6200 | 0.5838 | 0.8140 |
| 140 | 4.4053 | 6.5359 | 3.1153 | 0.5695 | 0.8487 |
| 150 | ..... | 7.8125 | 4.0000 | 0.5577 | 0.8913 |
| 160 | ..... | ..... | ..... | ..... | 0.9424 |
| 170 | ..... | ..... | ..... | ..... | 1.0044 |
| 180 | ..... | ..... | ..... | ..... | 1.0782 |
| 190 | ..... | ..... | ..... | ..... | 1.1710 |
| 200 | ..... | ..... | ..... | ..... | 1.2786 |
| 210 | ..... | ..... | ..... | ..... | 1.4156 |
| 220 | ..... | ..... | ..... | ..... | 1.5913 |
| 230 | ..... | ..... | ..... | ..... | 1.8235 |
| 240 | ..... | ..... | ..... | ..... | 2.1381 |
| 0-5 | 0.1650 | 0.1802 | 0.2217 | 0.3313 | 0.2451 |
| 3-9 | 0.2734 | 0.4632 | 0.5500 | 0.4510 | 0.4939 |
| 9-15 | 0.7634 | 0.7911 | 1.0299 | 0.5838 | 0.7680 |
| 15+ | 3.5461 | 1.2270 | 1.5870 | 0.5646 | 0.9816 |

Table XV. -- Yields per Acre of Well-Stocked Stands of the Jack Pine Cover Type in the Lake States

Good Site -- Index 66

| Main-stand age (years) | Average main-stand d.b.h. | Main-stand trees | Basal area, trees 1.0 inch or more in d.b.h. | Volume | | | |
|---|---|---|---|---|---|---|---|
| | | | | Trees 9.0 inches or more in d.b.h. | | Trees 5.0 inches or more in d.b.h. | |
| | | | | Scribner rule | Int'l ¼-inch rule | | |
| | Inches | Number | Sq.ft. | Bd.ft. | Bd.ft. | Cu.ft. | Cords |
| 20 | 4.3 | 1,320 | 133 | ..... | ..... | 660 | 9 |
| 30 | 6.3 | 670 | 146 | 900 | 1,150 | 1,410 | 20 |
| 40 | 8.0 | 435 | 150 | 2,250 | 2,800 | 2,020 | 28 |
| 50 | 9.3 | 320 | 152 | 3,900 | 4,800 | 2,440 | 34 |
| 60 | 10.4 | 255 | 151 | 5,650 | 6,850 | 2,700 | 38 |
| 70 | 11.4 | 210 | 149 | 7,300 | 8,700 | 2,870 | 40 |
| 80 | 12.2 | 180 | 144 | 8,400 | 9,900 | 2,910 | 40 |

Average Site -- Index 53

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 3.7 | 1,700 | 128 | ..... | ..... | 480 | 7 |
| 30 | 5.4 | 875 | 140 | 500 | 650 | 1,050 | 15 |
| 40 | 6.8 | 570 | 143 | 1,150 | 1,500 | 1,550 | 22 |
| 50 | 7.9 | 425 | 144 | 2,100 | 2,650 | 1,910 | 27 |
| 60 | 8.8 | 340 | 142 | 3,050 | 3,750 | 2,160 | 30 |
| 70 | 9.6 | 280 | 139 | 3,950 | 4,850 | 2,300 | 32 |
| 80 | 10.2 | 230 | 133 | 4,650 | 5,650 | 2,330 | 32 |

Poor Site -- Index 40

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 3.0 | 2,365 | 119 | ..... | ..... | 290 | 4 |
| 30 | 4.4 | 1,245 | 131 | ..... | ..... | 670 | 10 |
| 40 | 5.4 | 840 | 134 | ..... | ..... | 1,010 | 14 |
| 50 | 6.2 | 635 | 135 | 800 | 1,050 | 1,290 | 18 |
| 60 | 6.9 | 510 | 132 | 1,150 | 1,450 | 1,470 | 21 |
| 70 | 7.5 | 410 | 126 | 1,550 | 1,950 | 1,580 | 22 |
| 80 | 8.0 | 330 | 115 | 1,750 | 2,200 | 1,570 | 22 |

Table XVI. -- Yields per Acre of Well-Stocked Stands of the Red Pine Cover Type in the Lake States

Average Site -- Index 52

| Main-stand age (years) | Average main-stand d.b.h. | Main-stand trees | Basal area, trees 1.0 inch or more in d.b.h. | Volume | | | |
|---|---|---|---|---|---|---|---|
| | | | | Trees 9.0 inches or more in d.b.h. | | Trees 5.0 inches or more in d.b.h. | |
| | | | | Scribner rule | Int'l ¼-inch rule | | |
| | Inches | Number | Sq.ft. | Bd.ft. | Bd.ft. | Cu.ft. | Cords |
| 20 | 3.0 | 2,585 | 128 | ..... | ..... | 300 | 4 |
| 30 | 4.7 | 1,180 | 143 | 500 | 650 | 940 | 13 |
| 40 | 6.3 | 730 | 157 | 1,250 | 1,600 | 1,630 | 23 |
| 50 | 7.7 | 525 | 169 | 2,550 | 3,200 | 2,370 | 34 |
| 60 | 8.9 | 420 | 180 | 4,650 | 5,700 | 3,150 | 44 |
| 70 | 9.9 | 355 | 190 | 7,400 | 9,000 | 3,880 | 54 |
| 80 | 10.8 | 310 | 198 | 10,000 | 12,000 | 4,440 | 62 |
| 90 | 11.4 | 285 | 203 | 11,900 | 14,150 | 4,850 | 67 |
| 100 | 11.9 | 265 | 207 | 13,150 | 15,550 | 5,100 | 71 |

Table XVII. -- Yields per Acre of Well-Stocked Stands of the White Pine Cover Type in the Lake States

Average Site -- Index 60

| Main-stand age (years) | Average main-stand d.b.h. | Main-stand trees | Basal area, trees 1.0 inch or more in d.b.h. | Volume | | | |
|---|---|---|---|---|---|---|---|
| | | | | Trees 9.0 inches or more in d.b.h. | | Trees 5.0 inches or more in d.b.h. | |
| | | | | Scribner rule | Int'l $\frac{1}{4}$-inch rule | | |
| | Inches | Number | Sq.ft. | Bd.ft. | Bd.ft. | Cu.ft. | Cords |
| 20 | 2.6 | 3,480 | 128 | ..... | ..... | 210 | 3 |
| 30 | 4.5 | 1,490 | 166 | 450 | 600 | 1,160 | 17 |
| 40 | 6.2 | 880 | 187 | 1,650 | 2,100 | 2,440 | 35 |
| 50 | 7.8 | 600 | 200 | 4,650 | 5,850 | 3,530 | 50 |
| 60 | 9.2 | 455 | 208 | 8,050 | 9,950 | 4,290 | 60 |
| 70 | 10.4 | 365 | 214 | 11,100 | 13,450 | 4,850 | 68 |
| 80 | 11.4 | 305 | 219 | 13,800 | 16,400 | 5,280 | 73 |
| 90 | 12.4 | 265 | 222 | 16,200 | 19,000 | 5,600 | 77 |
| 100 | 13.2 | 235 | 224 | 18,350 | 21,300 | 5,860 | 80 |
| 110 | 13.9 | 215 | 226 | 20,150 | 23,200 | 6,060 | 83 |
| 120 | 14.6 | 195 | 227 | 21,650 | 24,800 | 6,230 | 85 |
| 130 | 15.1 | 185 | 228 | 22,900 | 26,100 | 6,360 | 86 |
| 140 | 15.6 | 175 | 229 | 23,900 | 27,100 | 6,460 | 87 |

Table XVIII. -- Yields per Acre of Well-Stocked Stands of the Northern Hardwood Cover Type in the Lake States

Good Site

| Main-stand age (years) | Average main-stand d.b.h. | Main-stand trees | Basal area, trees 1.0 inch or more in d.b.h. | Volume | | | |
|---|---|---|---|---|---|---|---|
| | | | | Trees 9.0 inches or more in d.b.h. | | Trees 5.0 inches or more in d.b.h. | |
| | | | | Scribner rule | Int'l $\frac{1}{4}$-inch rule | | |
| | Inches | Number | Sq.ft. | Bd.ft. | Bd.ft. | Cu.ft. | Cords |
| 40 | 7.4 | 445 | 133 | 2,000 | 2,500 | 1,600 | 28 |
| 60 | 9.6 | 315 | 159 | 6,200 | 7,500 | 2,920 | 50 |
| 80 | 11.6 | 240 | 177 | 10,300 | 12,100 | 3,880 | 65 |
| 100 | 13.3 | 200 | 192 | 13,800 | 15,900 | 4,630 | 76 |
| 120 | 15.1 | 160 | 202 | 16,600 | 18,800 | 5,200 | 84 |
| 140 | 16.8 | 140 | 212 | 19,000 | 21,200 | 5,680 | 90 |
| 160 | 18.6 | 115 | 219 | 21,000 | 23,100 | 6,100 | 94 |
| 180 | 20.4 | 100 | 226 | 22,600 | 24,700 | 6,450 | 97 |
| 200 | 22.1 | 90 | 233 | 23,800 | 25,800 | 6,780 | 100 |

Average Site

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 40 | 5.6 | 675 | 115 | 600 | 750 | 1,140 | 20 |
| 60 | 7.8 | 410 | 136 | 2,550 | 3,150 | 2,090 | 37 |
| 80 | 9.5 | 305 | 150 | 5,650 | 6,850 | 2,850 | 49 |
| 100 | 10.9 | 250 | 162 | 8,400 | 10,000 | 3,490 | 59 |
| 120 | 12.2 | 215 | 173 | 10,900 | 12,750 | 4,030 | 67 |
| 140 | 13.5 | 185 | 183 | 13,150 | 15,150 | 4,490 | 74 |
| 160 | 14.8 | 160 | 191 | 15,000 | 17,050 | 4,880 | 79 |
| 180 | 16.1 | 140 | 199 | 16,550 | 18,550 | 5,210 | 83 |
| 200 | 17.4 | 125 | 205 | 17,750 | 19,800 | 5,480 | 86 |
| 220 | 18.7 | 110 | 209 | 18,700 | 20,600 | 5,700 | 88 |

Poor Site

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 40 | 4.1 | 1,055 | 97 | 300 | 400 | 500 | 9 |
| 60 | 6.0 | 600 | 117 | 700 | 900 | 1,370 | 24 |
| 80 | 7.6 | 420 | 132 | 2,100 | 2,600 | 2,100 | 37 |
| 100 | 8.9 | 335 | 144 | 4,350 | 5,300 | 2,700 | 47 |
| 120 | 10.0 | 280 | 154 | 6,500 | 7,850 | 3,200 | 55 |
| 140 | 11.0 | 245 | 162 | 8,350 | 9,900 | 3,600 | 61 |
| 160 | 11.9 | 220 | 169 | 9,750 | 11,450 | 3,930 | 65 |
| 180 | 12.9 | 195 | 176 | 10,800 | 12,550 | 4,170 | 69 |
| 200 | 13.8 | 175 | 180 | 11,550 | 13,250 | 4,340 | 71 |
| 220 | 14.8 | 155 | 183 | 11,950 | 13,600 | 4,440 | 71 |

Table XIX. -- Yields per Acre of Well-Stocked Stands of the Oak Cover Type in the Lake States

Good Site

| Main-stand age (years) | Average main-stand d.b.h. | Main-stand trees | Basal area, trees 1.0 inch or more in d.b.h. | Volume | | | |
|---|---|---|---|---|---|---|---|
| | | | | Trees 9.0 inches or more in d.b.h. | | Trees 5.0 inches or more in d.b.h. | |
| | | | | Scribner rule | Int'l ¼-inch rule | | |
| | Inches | Number | Sq.ft. | Bd.ft. | Bd.ft. | Cu.ft. | Cords |
| 20 | 4.2 | 1,000 | 96 | ..... | ..... | 500 | 9 |
| 30 | 6.2 | 535 | 112 | 650 | 800 | 1,300 | 23 |
| 40 | 8.1 | 340 | 122 | 2,200 | 2,700 | 2,020 | 35 |
| 50 | 9.9 | 240 | 127 | 5,200 | 6,300 | 2,550 | 43 |
| 60 | 11.5 | 180 | 130 | 7,950 | 9,350 | 2,980 | 50 |
| 70 | 13.0 | 140 | 132 | 10,000 | 11,600 | 3,320 | 54 |
| 80 | 14.5 | 115 | 133 | 11,400 | 13,000 | 3,560 | 57 |
| 90 | 15.8 | 100 | 133 | 12,400 | 13,950 | 3,730 | 59 |
| 100 | 17.0 | 85 | 132 | 13,100 | 14,600 | 3,840 | 60 |

Average Site

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 2.9 | 1,740 | 81 | ..... | ..... | 190 | 3 |
| 30 | 4.8 | 835 | 105 | ..... | ..... | 670 | 12 |
| 40 | 6.6 | 495 | 117 | 700 | 850 | 1,350 | 24 |
| 50 | 8.2 | 340 | 123 | 2,000 | 2,450 | 1,920 | 33 |
| 60 | 9.6 | 250 | 126 | 4,400 | 5,300 | 2,340 | 40 |
| 70 | 11.0 | 195 | 128 | 6,650 | 7,900 | 2,650 | 45 |
| 80 | 12.3 | 160 | 129 | 8,300 | 9,700 | 2,870 | 47 |
| 90 | 13.4 | 135 | 129 | 9,350 | 10,800 | 3,020 | 49 |
| 100 | 14.4 | 115 | 129 | 10,000 | 11,400 | 3,120 | 50 |
| 110 | 15.4 | 100 | 127 | 10,450 | 11,800 | 3,170 | 51 |

Poor Site

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 1.8 | 3,560 | 64 | ..... | ..... | 60 | 1 |
| 30 | 3.6 | 1,240 | 88 | ..... | ..... | 290 | 5 |
| 40 | 5.1 | 740 | 104 | ..... | ..... | 710 | 13 |
| 50 | 6.6 | 475 | 114 | 650 | 800 | 1,210 | 21 |
| 60 | 8.0 | 340 | 118 | 1,600 | 2,000 | 1,670 | 29 |
| 70 | 9.2 | 260 | 121 | 3,400 | 4,150 | 1,990 | 34 |
| 80 | 10.4 | 205 | 122 | 5,250 | 6,300 | 2,190 | 37 |
| 90 | 11.5 | 170 | 122 | 6,400 | 7,550 | 2,330 | 39 |
| 100 | 12.4 | 145 | 120 | 7,100 | 8,300 | 2,410 | 40 |
| 110 | 13.2 | 120 | 116 | 7,450 | 8,600 | 2,440 | 40 |

Table XX. -- Yields per Acre of Well-Stocked Stands of the Aspen Cover Type in the Lake States

Good Site -- Index 70 -- Typical of Hardwood Land

| Main-stand age (years) | Average main-stand d.b.h. | Main-stand trees | Basal area, trees 1.0 inch or more in d.b.h. | Volume | | | |
|---|---|---|---|---|---|---|---|
| | | | | Trees 9.0 inches or more in d.b.h. | | Trees 5.0 inches or more in d.b.h. | |
| | | | | Scribner rule | Int'l $\frac{1}{4}$-inch rule | | |
| | Inches | Number | Sq.ft. | Bd.ft. | Bd.ft. | Cu.ft. | Cords |
| 20 | 2.8 | 1,785 | 76 | ..... | ..... | 150 | 2 |
| 30 | 4.5 | 875 | 95 | ..... | ..... | 710 | 11 |
| 40 | 6.1 | 540 | 109 | 500 | 600 | 1,450 | 23 |
| 50 | 7.7 | 365 | 118 | 1,800 | 2,250 | 2,160 | 34 |
| 60 | 9.2 | 270 | 125 | 5,100 | 6,300 | 2,720 | 42 |
| 70 | 10.4 | 215 | 127 | 6,900 | 8,350 | 3,030 | 46 |
| 80 | 11.4 | 175 | 127 | 7,600 | 9,050 | 3,150 | 48 |

Average Site -- Index 65 -- Typical of Spruce-Balsam Land

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 2.6 | 2,030 | 73 | ..... | ..... | 110 | 2 |
| 30 | 4.1 | 990 | 91 | ..... | ..... | 570 | 9 |
| 40 | 5.6 | 605 | 105 | 350 | 450 | 1,230 | 20 |
| 50 | 7.1 | 410 | 114 | 1,100 | 1,350 | 1,900 | 30 |
| 60 | 8.6 | 295 | 118 | 3,500 | 4,350 | 2,430 | 38 |
| 70 | 9.7 | 230 | 119 | 5,750 | 7,000 | 2,730 | 42 |
| 80 | 10.6 | 190 | 116 | 6,400 | 7,750 | 2,780 | 43 |

Poor Site -- Index 60 -- Typical of Pine Land

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 2.3 | 2,455 | 69 | ..... | ..... | 80 | 1 |
| 30 | 3.7 | 1,155 | 86 | ..... | ..... | 390 | 6 |
| 40 | 5.1 | 690 | 99 | ..... | ..... | 980 | 16 |
| 50 | 6.5 | 470 | 107 | 650 | 800 | 1,570 | 25 |
| 60 | 7.8 | 340 | 111 | 1,800 | 2,250 | 2,060 | 32 |
| 70 | 8.8 | 260 | 110 | 3,900 | 4,850 | 2,340 | 36 |
| 80 | 9.6 | 200 | 99 | 4,550 | 5,600 | 2,230 | 34 |

Table XXI. -- Yields per Acre of Well-Stocked Stands of the Balsam Fir Cover Type in the Lake States

Average Site

| Main-stand age (years) | Average main-stand d.b.h. | Main-stand trees | Basal area, trees 1.0 inch or more in d.b.h. | Volume | | | |
|---|---|---|---|---|---|---|---|
| | | | | Trees 9.0 inches or more in d.b.h. | | Trees 5.0 inches or more in d.b.h. | |
| | | | | Scribner rule | Int'l $\frac{1}{4}$-inch rule | | |
| | Inches | Number | Sq.ft. | Bd.ft. | Bd.ft. | Cu.ft. | Cords |
| 20 | 2.0 | 6,090 | 127 | ..... | ..... | 120 | 2 |
| 30 | 3.5 | 2,260 | 153 | 650 | 850 | 700 | 10 |
| 40 | 4.8 | 1,245 | 157 | 1,500 | 1,950 | 1,540 | 22 |
| 50 | 6.0 | 800 | 156 | 2,450 | 3,100 | 1,920 | 27 |
| 60 | 7.0 | 570 | 151 | 3,250 | 4,100 | 2,130 | 30 |
| 70 | 7.9 | 420 | 143 | 3,950 | 4,900 | 2,220 | 31 |
| 80 | 8.7 | 325 | 133 | 4,350 | 5,400 | 2,200 | 31 |
| 90 | 9.3 | 255 | 121 | 4,500 | 5,550 | 2,100 | 29 |

Table XXII. -- Yields per Acre of Well-Stocked Stands of the Black Spruce Cover Type in the Lake States

Average Site

| Main-stand age (years) | Average main-stand d.b.h. | Main-stand trees | Basal area, trees 1.0 inch or more in d.b.h. | Volume | | | |
|---|---|---|---|---|---|---|---|
| | | | | Trees 9.0 inches or more in d.b.h. | | Trees 5.0 inches or more in d.b.h. | |
| | | | | Scribner rule | Int'l ¼-inch rule | | |
| | Inches | Number | Sq.ft. | Bd.ft. | Bd.ft. | Cu.ft. | Cords |
| 30..... | 1.6 | 7,290 | 98 | ..... | ..... | 70 | 1 |
| 40..... | 2.7 | 3,010 | 123 | ..... | ..... | 260 | 4 |
| 50..... | 3.9 | 1,675 | 141 | ..... | ..... | 660 | 9 |
| 60..... | 5.0 | 1,120 | 151 | ..... | ..... | 1,060 | 15 |
| 70..... | 5.9 | 830 | 157 | 700 | 900 | 1,440 | 21 |
| 80..... | 6.7 | 660 | 162 | 1,200 | 1,500 | 1,760 | 25 |
| 90..... | 7.4 | 555 | 165 | 1,950 | 2,450 | 2,020 | 29 |
| 100..... | 8.0 | 485 | 167 | 2,800 | 3,550 | 2,220 | 32 |
| 110..... | 8.5 | 430 | 169 | 3,600 | 4,450 | 2,390 | 34 |
| 120..... | 8.9 | 395 | 170 | 4,250 | 5,300 | 2,520 | 35 |
| 130..... | 9.3 | 360 | 170 | 4,850 | 5,950 | 2,620 | 36 |
| 140..... | 9.6 | 335 | 169 | 5,350 | 6,500 | 2,690 | 37 |
| 150..... | 9.9 | 315 | 168 | 5,700 | 6,950 | 2,740 | 38 |

Table XXIII. -- Yields per Acre of Well-Stocked Stands of the Bottomland Hardwood Cover Type in the Lake States

Southern Type

| Main-stand age (years) | Average main-stand d.b.h. | Main-stand trees | Basal area, trees 1.0 inch or more in d.b.h. | Volume | | | |
|---|---|---|---|---|---|---|---|
| | | | | Trees 9.0 inches or more in d.b.h. | | Trees 5.0 inches or more in d.b.h. | |
| | | | | Scribner rule | Int'l $\frac{1}{4}$-inch rule | | |
| | Inches | Number | Sq.ft. | Bd.ft. | Bd.ft. | Cu.ft. | Cords |
| 20 | 4.7 | 875 | 104 | 400 | 500 | 900 | 16 |
| 30 | 6.5 | 560 | 130 | 1,250 | 1,550 | 1,700 | 30 |
| 40 | 8.0 | 415 | 145 | 2,500 | 3,150 | 2,320 | 40 |
| 50 | 9.2 | 335 | 156 | 4,150 | 5,100 | 2,850 | 49 |
| 60 | 10.4 | 280 | 164 | 6,000 | 7,200 | 3,280 | 56 |
| 70 | 11.4 | 240 | 170 | 7,600 | 9,000 | 3,630 | 61 |
| 80 | 12.4 | 205 | 173 | 8,800 | 10,300 | 3,870 | 64 |
| 90 | 13.2 | 180 | 173 | 9,650 | 11,200 | 4,030 | 66 |
| 100 | 13.9 | 160 | 171 | 10,250 | 11,750 | 4,090 | 66 |

Northern type

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 3.6 | 1,130 | 80 | ..... | ..... | 340 | 6 |
| 30 | 5.2 | 740 | 109 | 500 | 600 | 1,000 | 18 |
| 40 | 6.7 | 520 | 128 | 1,200 | 1,500 | 1,590 | 28 |
| 50 | 7.9 | 415 | 141 | 2,150 | 2,650 | 2,080 | 36 |
| 60 | 8.9 | 345 | 150 | 3,250 | 3,950 | 2,470 | 43 |
| 70 | 9.8 | 300 | 157 | 4,450 | 5,400 | 2,810 | 48 |
| 80 | 10.7 | 260 | 162 | 5,600 | 6,700 | 3,090 | 52 |
| 90 | 11.5 | 230 | 166 | 6,700 | 7,950 | 3,310 | 56 |
| 100 | 12.2 | 205 | 168 | 7,550 | 8,850 | 3,490 | 58 |
| 110 | 12.9 | 185 | 169 | 8,250 | 9,550 | 3,620 | 60 |
| 120 | 13.5 | 170 | 168 | 8,750 | 10,050 | 3,700 | 60 |
| 130 | 14.0 | 155 | 166 | 9,100 | 10,400 | 3,730 | 60 |

Table XXIV. -- Percentage Growth in Board Feet (Scribner), for Any Period, of Trees of All Species in the Lake States, by D. B. H. Class and Rate of Diameter Increment

Hardwoods

| Diameter breast high (inches) | Growth, in percent of present sawlog volume, by increment in d.b.h. (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.2 inches | 0.4 inches | 0.6 inches | 0.8 inches | 1.0 inches | 1.2 inches | 1.4 inches | 1.6 inches | 1.8 inches | 2.0 inches | 3.0 inches | 4.0 inches |
| 10 | 24.1 | 48.1 | 73.4 | 98.8 | 126 | 150 | 176 | 202 | 228 | 256 | 390 | 533 |
| 11 | 10.6 | 22.4 | 33.9 | 45.1 | 57.6 | 69.1 | 80.9 | 93.2 | 105 | 117 | 180 | 251 |
| 12 | 7.3 | 14.7 | 22.5 | 30.0 | 37.4 | 45.2 | 52.8 | 61.2 | 69.8 | 77.6 | 123 | 174 |
| 13 | 5.7 | 11.2 | 17.3 | 23.6 | 29.2 | 35.4 | 41.5 | 48.5 | 55.2 | 62.6 | 99.0 | 140 |

Conifers and Aspen

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 6.0 | 13.3 | 20.6 | 28.8 | 38.0 | 48.1 | 57.9 | 68.0 | 78.5 | 90.5 | 153 | 224 |
| 11 | 7.3 | 14.4 | 21.8 | 29.4 | 38.1 | 46.6 | 55.7 | 65.1 | 74.3 | 83.5 | 135 | 195 |
| 12 | 6.1 | 12.8 | 19.6 | 26.2 | 32.9 | 40.0 | 47.5 | 54.6 | 62.8 | 70.3 | 114 | 162 |
| 13 | 5.4 | 11.0 | 16.4 | 22.5 | 28.1 | 34.2 | 40.2 | 47.2 | 53.9 | 60.8 | 97.2 | 138 |

All Species

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 4.8 | 9.5 | 14.9 | 20.1 | 25.5 | 30.8 | 36.6 | 42.2 | 48.1 | 54.0 | 85.6 | 121 |
| 15 | 4.3 | 8.9 | 13.4 | 18.0 | 22.7 | 27.4 | 32.3 | 37.4 | 42.4 | 47.9 | 75.9 | 106 |
| 16 | 3.8 | 7.8 | 12.0 | 16.1 | 20.5 | 24.9 | 29.5 | 34.1 | 38.7 | 43.3 | 67.9 | 94.4 |
| 17 | 3.6 | 7.4 | 11.2 | 15.1 | 18.9 | 23.0 | 27.1 | 31.3 | 35.3 | 39.3 | 61.3 | 84.8 |
| 18 | 3.4 | 6.9 | 10.4 | 13.7 | 17.2 | 20.7 | 24.3 | 28.0 | 31.8 | 35.6 | 55.3 | 76.1 |
| 19 | 3.0 | 6.1 | 9.3 | 12.5 | 15.8 | 19.0 | 22.3 | 25.7 | 29.1 | 32.6 | 50.3 | 69.4 |
| 20 | 2.8 | 5.7 | 8.6 | 11.5 | 14.5 | 17.6 | 20.6 | 23.7 | 26.7 | 29.8 | 46.3 | 63.1 |
| 21 | 2.6 | 5.3 | 8.0 | 10.6 | 13.4 | 16.1 | 19.0 | 21.9 | 24.8 | 27.7 | 42.4 | 57.8 |
| 22 | 2.4 | 4.9 | 7.5 | 10.0 | 12.6 | 15.2 | 17.8 | 20.5 | 23.0 | 25.6 | 39.2 | 52.8 |
| 23 | 2.3 | 4.6 | 7.0 | 9.2 | 11.5 | 13.9 | 16.3 | 18.8 | 21.1 | 23.5 | 35.6 | 48.0 |
| 24 | 2.2 | 4.3 | 6.5 | 8.6 | 10.8 | 12.8 | 15.0 | 17.2 | 19.4 | 21.6 | 32.7 | 43.8 |

Table XXV. -- Percentage Growth in Cubic Feet, for Any Period, of Trees of All Species in the Lake States, by D. B. H. Class and Rate of Diameter Increment

| Diameter breast high (inches) | Growth, in percent of present cubic volume, by increment in d.b.h. (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.2 inches | 0.4 inches | 0.6 inches | 0.8 inches | 1.0 inches | 1.2 inches | 1.4 inches | 1.6 inches | 1.8 inches | 2.0 inches | 3.0 inches | 4.0 inches |
| 6..... | 12.8 | 27.4 | 40.1 | 54.9 | 69,5 | 85.5 | 104 | 122 | 141 | 163 | 272 | 400 |
| 7..... | 9.6 | 20.7 | 30.5 | 42.3 | 53.0 | 65.3 | 77.1 | 90.0 | 104 | 120 | 194 | 278 |
| 8..... | 7.7 | 16.4 | 24.4 | 33.5 | 42.3 | 51.7 | 60.8 | 70.3 | 81.2 | 92.2 | 148 | 212 |
| 9..... | 6.5 | 13.5 | 20.4 | 27.7 | 34.7 | 42.6 | 50.0 | 57.6 | 66.4 | 74.1 | 119 | 168 |
| 10..... | 5.6 | 11.4 | 17.5 | 23.3 | 29.5 | 36.0 | 42.5 | 49.1 | 56.0 | 62.2 | 99.0 | 140 |
| 11..... | 4.9 | 9.8 | 15.2 | 20.4 | 25.7 | 31.2 | 37.1 | 43.0 | 48.6 | 54.1 | 85.3 | 119 |
| 12..... | 4.4 | 8.8 | 13.5 | 18.1 | 22.9 | 27.8 | 32.9 | 38.2 | 43.1 | 47.8 | 75.3 | 104 |
| 13..... | 4.0 | 7.9 | 12.1 | 16.3 | 20.6 | 24.8 | 29.5 | 34.3 | 38.8 | 43.0 | 67.2 | 93.0 |
| 14..... | 3.6 | 7.2 | 11.0 | 14.7 | 18.7 | 22.5 | 26.7 | 30.9 | 35.0 | 38.8 | 60.2 | 83.3 |
| 15..... | 3.3 | 6.6 | 10.0 | 13.6 | 17.2 | 20.6 | 24.4 | 28.3 | 32.1 | 35.6 | 55.4 | 75.8 |
| 16..... | 3.1 | 6.1 | 9.3 | 12.5 | 15.8 | 19.1 | 22.3 | 26.1 | 29.6 | 32.7 | 50.7 | 69.9 |
| 17..... | 2.9 | 5.7 | 8.7 | 11.7 | 14.6 | 17.7 | 20.7 | 24.2 | 27.3 | 30.2 | 46.8 | 64.1 |
| 18..... | 2.7 | 5.3 | 8.1 | 10.9 | 13.6 | 16.5 | 19.4 | 22.4 | 25.4 | 28.2 | 43.3 | 59.7 |
| 19..... | 2.5 | 5.0 | 7.6 | 10.2 | 12.7 | 15.4 | 18.1 | 20.9 | 23.7 | 26.3 | 40.5 | 55.5 |
| 20..... | 2.3 | 4.7 | 7.2 | 9.6 | 11.9 | 14.5 | 16.9 | 19.6 | 22.3 | 24.7 | 37.7 | 51.9 |
| 21..... | 2.2 | 4.4 | 6.8 | 9.1 | 11.2 | 13.6 | 16.0 | 18.5 | 21.1 | 23.3 | 35.5 | 48.8 |
| 22..... | 2.1 | 4.2 | 6.4 | 8.6 | 10.6 | 12.9 | 15.1 | 17.5 | 19.9 | 22.0 | 33.4 | 45.9 |
| 23..... | 2.0 | 4.0 | 6.1 | 8.2 | 10.0 | 12.3 | 14.3 | 16.6 | 18.9 | 20.8 | 31.6 | 43.3 |
| 24..... | 1.9 | 3.9 | 5.8 | 7.8 | 9.5 | 11.7 | 13.6 | 15.7 | 18.0 | 19.8 | 29.8 | 41.1 |

Table XXVI. -- Percentage Growth in Cords, for Any Period, of Trees of All Species in the Lake States, by D.B.H. Class and Rate of Diameter Increment

| Diameter breast high (Inches) | Growth, in percent of present cordwood volume, by increment in d.b.h. (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.2 inches | 0.4 inches | 0.6 inches | 0.8 inches | 1.0 inches | 1.2 inches | 1.4 inches | 1.6 inches | 1.8 inches | 2.0 inches | 3.0 inches | 4.0 inches |
| 6..... | 12.4 | 26.7 | 39.0 | 53.4 | 67.3 | 82.8 | 100 | 118 | 136 | 157 | 258 | 376 |
| 7..... | 9.3 | 20.1 | 29.7 | 41.0 | 51.2 | 63.0 | 74.1 | 86.4 | 99.6 | 115 | 184 | 260 |
| 8..... | 7.5 | 15.9 | 23.5 | 32.2 | 40.5 | 49.6 | 58.2 | 67.1 | 77.4 | 87.7 | 140 | 198 |
| 9..... | 6.3 | 13.1 | 19.6 | 26.6 | 33.2 | 40.7 | 47.6 | 54.8 | 63.1 | 70.1 | 112 | 156 |
| 10..... | 5.4 | 10.9 | 16.7 | 22.2 | 28.0 | 34.1 | 40.2 | 46.4 | 52.8 | 58.5 | 92.2 | 129 |
| 11..... | 4.7 | 9.3 | 14.4 | 19.3 | 24.3 | 29.3 | 34.9 | 40.4 | 45.5 | 50.7 | 79.1 | 109 |
| 12..... | 4.1 | 8.3 | 12.7 | 17.0 | 21.5 | 26.1 | 30.8 | 35.7 | 40.2 | 44.5 | 69.5 | 95.1 |
| 13..... | 3.8 | 7.4 | 11.4 | 15.2 | 19.3 | 23.1 | 27.5 | 32.0 | 36.1 | 39.9 | 61.8 | 84.7 |
| 14..... | 3.4 | 6.7 | 10.3 | 13.7 | 17.4 | 20.9 | 24.7 | 28.6 | 32.3 | 35.8 | 55.0 | 75.5 |
| 15..... | 3.1 | 6.1 | 9.3 | 12.7 | 16.0 | 19.0 | 22.6 | 26.1 | 29.6 | 32.7 | 50.5 | 68.5 |
| 16..... | 2.9 | 5.6 | 8.5 | 11.6 | 14.6 | 17.6 | 20.5 | 23.9 | 27.1 | 29.9 | 46.0 | 62.8 |
| 17..... | 2.7 | 5.3 | 8.0 | 10.7 | 13.4 | 16.2 | 19.0 | 22.1 | 24.9 | 27.5 | 42.2 | 57.3 |
| 18..... | 2.5 | 4.9 | 7.5 | 9.9 | 12.4 | 15.0 | 17.6 | 20.3 | 23.1 | 25.5 | 38.8 | 53.2 |
| 19..... | 2.2 | 4.5 | 6.9 | 9.2 | 11.5 | 13.9 | 16.4 | 19.0 | 21.4 | 23.7 | 36.2 | 49.1 |
| 20..... | 2.1 | 4.3 | 6.6 | 8.7 | 10.7 | 13.1 | 15.3 | 17.6 | 20.1 | 22.2 | 33.5 | 45.8 |
| 21..... | 2.0 | 3.9 | 6.1 | 8.2 | 10.1 | 12.2 | 14.4 | 16.5 | 18.9 | 20.9 | 31.5 | 42.9 |
| 22..... | 1.8 | 3.8 | 5.7 | 7.7 | 9.5 | 11.4 | 13.5 | 15.6 | 17.7 | 19.6 | 29.4 | 40.2 |
| 23..... | 1.8 | 3.6 | 5.5 | 7.3 | 8.9 | 10.9 | 12.7 | 14.7 | 16.7 | 18.4 | 27.8 | 37.8 |
| 24..... | 1.7 | 3.6 | 5.2 | 7.0 | 8.4 | 10.3 | 12.0 | 13.8 | 15.9 | 17.5 | 26.1 | 35.7 |

Table XXVII. -- Height of Dominant Trees as Index of Site Quality in the Lake States, by Forest Cover Type

| Age of stand (years) | Average total height of dominants, by site quality and type | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Good | | | | Average | | | | Poor | | | |
| | Jack pine | Aspen | Red pine | White pine | Jack pine | Aspen | Red pine | White pine | Jack pine | Aspen | Red pine | White pine |
| | Feet | Feet | Feet | Feet | Feet | Feet | Feet | Feet | Feet | Feet | Feet | Feet |
| 20.... | .... | 40 | .... | ..... | .... | 37 | .... | ..... | .... | 34 | .... | ..... |
| 30.... | 44 | 51 | 37 | 38 | 35 | 48 | 31 | 32 | 27 | 44 | 24 | 27 |
| 40.... | 56 | 62 | 49 | 55 | 45 | 57 | 43 | 47 | 34 | 53 | 33 | 39 |
| 50.... | 66 | 70 | 60 | 70 | 53 | 65 | 52 | 60 | 40 | 60 | 40 | 50 |
| 60.... | 75 | 76 | 69 | 82 | 60 | 71 | 60 | 71 | 45 | 66 | 46 | 59 |
| 70.... | 81 | 82 | 76 | 93 | 65 | 76 | 67 | 80 | 49 | 70 | 51 | 67 |
| 80.... | 86 | 86 | 82 | 103 | 69 | 80 | 72 | 88 | 52 | 74 | 55 | 74 |
| 90.... | .... | ..... | 88 | 110 | .... | ..... | 76 | 94 | .... | ..... | 58 | 79 |
| 100... | .... | ..... | 93 | 115 | .... | ..... | 80 | 99 | .... | ..... | 62 | 83 |
| 110... | .... | ..... | .... | 120 | .... | ..... | .... | 103 | .... | ..... | .... | 86 |
| 120... | .... | ..... | .... | 123 | .... | ..... | .... | 106 | .... | ..... | .... | 88 |

Table XXVIII. -- Bark Factors[1] for Tree Species in the Lake States

| Species | Bark factor | Species | Bark factor |
|---|---|---|---|
| Ash, black | 1.087 | Hickories | 1.087 |
| Ash, green | 1.117 | Hop-hornbeam[2] | 1.100 |
| Ash, red | 1.117 | Maple, red | 1.076 |
| Ash, white | 1.117 | Maple, silver | 1.076 |
| Aspen | 1.096 | Maple, sugar | 1.096 |
| Basswood | 1.104 | Oaks | 1.122 |
| Beech | 1.046 | Pine, jack | 1.107 |
| Birch, black | 1.099 | Pine, northern white | 1.117 |
| Birch, paper | 1.075 | Pine, red | 1.112 |
| Birch, yellow | 1.087 | Poplar, balsam[3] | 1.096 |
| Cedar, northern white | 1.099 | Poplar, yellow | 1.104 |
| Cherry, black | 1.087 | Spruce, black | 1.065 |
| Cottonwood | 1.096 | Spruce, white | 1.065 |
| Elms | 1.100 | Tamarack | 1.056 |
| Fir, balsam | 1.070 | Walnut, black | 1.087 |
| Hemlock | 1.124 | Willow, black | 1.096 |

[1] Multipliers for converting diameter increment of wood to total diameter increment. (Diameter increment of wood x bark factor = diameter increment of both wood and bark.)

[2] Commonly known in the Lake States as ironwood.

[3] Commonly known in the Lake States as balm-of-Gilead.